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Evaluation of Management of Water Release for Painted Rocks Reservoir, Bitterroot River, Montana

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EVALUATION OF MANAGEMENT OF WATER RELEASES FOR PAINTED ROCKS RESERVOIR, BITTERROOT RIVER, MONTANA

Annual Report FY1984

By

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ABSTRACT

Baseline fisheries and habitat data were gathered during 1983 and 1984 to evaluate the effectiveness of supplemental water releases from Painted Rocks Reservoir in improving the fisheries resource in the Bitterroot River. Discharge relationships among main stem gaging stations varied annually and seasonally. Flow relationships in the river were dependent upon rainfall events and the timing and duration of the irrigation season. Daily discharge monitored during the summers of 1983 and 1984 was greater than median values derived at the U.S.G.S. station near Darby. Supplemental water released from Painted Rocks Reservoir totaled 14,476 acre feet in 1983 and 13,958 acre feet in 1984. Approximately 63% of a 5.66 m^3/sec test release of supplemental water conducted during April, 1984 was lost to irrigation withdrawals and natural phenomena before passing Bell Crossing. A similar loss occurred during a 5.66 m^3/sec test release conducted in August, 1984. Daily maximum temperature monitored during 1984 in the Bitterroot River averaged 11.0, 12.5, 13.9 and 13.6 C at the Darby, Hamilton, Bell and McClay stations, respectively. Chemical parameters measured in the Bitterroot River were favorable to aquatic life. Population estimates conducted in the Fall, 1983 indicated densities of I+ and older rainbow trout (Salmo gairdneri) were significantly greater in a control section than in a dewatered section ($p<0.20$). Numbers of I+ and older brown trout (Salmo trutta) were not significantly different between the control and dewatered sections ($p>0.20$). Population and biomass estimates for trout in the control section were 631/km and 154.4 kg/km. In the dewatered section, population and biomass estimates for trout were 253/km and 122.8 kg/km. The growth increments of back-calculated length for rainbow trout averaged 75.6 mm in the control section and 66.9mm in the dewatered section. The growth increments of back-calculated length for brown trout averaged 79.5 mm in the control section and 82.3mm in the dewatered section. Population estimates conducted in the Spring, 1984 indicated densities of mountain whitefish (Prosopium williamsoni) greater than 254 mm in total length were not significantly different between the control and dewatered sections ($p>0.20$). Young of the year rainbow trout and brown trout per 10m of river edge electrofished during 1984 were more abundant in the control section than the dewatered section and were more abundant in side channel habitat than main channel habitat. Minimum flow recommendations obtained from wetted perimeter-discharge relationships averaged 8.5m^3/sec in the control section and 10.6m^3/sec in the dewatered section of the Bitterroot River. The quantity of supplemental water from Painted Rocks Reservoir needed to maintain minimum flow recommendations is discussed in the Draft Water Management Plan for the Proposed Purchase of Supplemental Water from Painted Rocks Reservoir, Bitterroot River, Montana (Lere 1984).

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INTRODUCTION

The Bitterroot River, located in western Montana, is an important and heavily used resource, providing water for agriculture and a source for diversified forms of recreation. Water shortages in the river, however, have been a persistent problem for both irrigators and recreational users. Five major diversions and numerous smaller canals remove substantial quantities of water from the river during the irrigation season. Historically, the river has been severely dewatered between the towns of Hamilton and Stevensville as a result of these withdrawals.

Demands for irrigation water from the Bitterroot River have often conflicted with the instream flow needs for trout. Withdrawals of water can decrease suitable depths, velocities, substrates and cover utilized by trout (Stalnaker and Arnette 1976, Wesche 1976). Losses in habitat associated with dewatering have been shown to diminish the carrying capacities for trout populations (Nelson 1980). Additionally, dewatering of the Bitterroot River has forced irrigators to dike or channelize the streambed to obtain needed flows. These alterations reduce aquatic habitat and degrade channel stability. Odell (personal communication) found a substantial reduction in the total biomass of aquatic insects within a section of the Bitterroot River that had been bulldozed for irrigation purposes.

The Montana Department of Fish, Wildlife and Parks (MDFWP) has submitted a proposal to the Northwest Power Planning Council for the purchase of 10,000 acre feet (AF) of stored water in Painted Rocks Reservoir to augment low summer flows in the Bitterroot River. This supplemental water potentially would enhance the fishery in the river and reduce the degradation of the channel due to diversion activities.

The present study was undertaken to: (1) develop an implementable water management plan for supplemental releases from Painted Rocks Reservoir which would provide optimum benefits to the river; (2) gather fisheries and habitat information to evaluate the effects of dewatering in the river; (3) obtain baseline information that would aid in determining the effectiveness of supplemental water releases in improving the fisheries resource. The study was initiated in July, 1983 and is scheduled to be completed in April, 1985.

DESCRIPTION OF STUDY AREA

The Bitterroot River is located in Ravalli and Missoula Counties in west central Montana (Figure 1). It originates at the confluence of the East Fork and West Fork of the Bitterroot River near the town of Conner and flows northerly for approximately 135 km (84 mi) to its confluence with the Clark Fork River at Missoula. The elevation of the river ranges from 1222 m (4010 ft) near Conner to 942 m (3090 ft) at Missoula. The gradient of the river averages about 3.22% (17 ft/mi) near Darby and about 0.57% (3 ft/mi) near Missoula (Figure 2). The basin drains approximately 725,212 hectares (2,800 mi^2).

From Conner to Sleeping Child Creek, the Bitterroot River flows through a relatively narrow mountain valley. Downstream from Sleeping Child Creek, the river bottom broadens into the farmlands of the Bitterroot Valley. Land use patterns of the basin, obtained from the Montana Statewide Cooperative Land Use Mapping Program (U.S. Dept. of Agriculture 1977) are shown in Appendix Figures 1 to 3. A majority of the valley bottom consists of irrigated cropland or pastureland. However, substantial acreage of the valley has been divided into parcels of less than 40 acres. These smaller parcels are shown as "rural and suburban" tracts on the land use maps. In association with these tracts, the development of subdivisions is common throughout the valley.

The streambed of the Bitterroot River is typified by large bars of deposited gravel and an extensive network of side channels. The wide riparian zone is dominated by a cottonwood (Populas spp.)/ Ponderosa Pine (Pinus ponderosa) overstory. Numerous developed and undeveloped recreational sites provide good access to the river.

The river valley is bordered on the west by the Bitterroot Mountains and on the east by the Sapphire Mountains. The Bitterroot Mountains receive up to 254 cm (100 in.) of annual precipitation and the Sapphire Mountains receive up to 127 cm (50 in) of precipitation (Senger 1973). A majority of the mountain precipitation is snowfall. Numerous tributaries drain the bordering mountains and supply water for irrigation to the farmlands of the valley. The west side streams exhibit greater seasonal fluctuations in flow than do the east side streams (McMurtrey et al. 1972). Tributaries from the mountains add considerable flow to the Bitterroot River during spring runoff but many are diverted for irrigation and contribute little flow during the summer and early fall.

Painted Rocks Reservoir is located on the West Fork of the Bitterroot River approximately 36 km (22 mi.) upstream from its confluence with the East Fork. The reservoir was completed in 1940 as a multi-purpose project and is operated by the Department of Natural Resources and Conservation (DNRC). The reservoir has a storage capacity of 32,362 acre feet (AF) and a surface area at

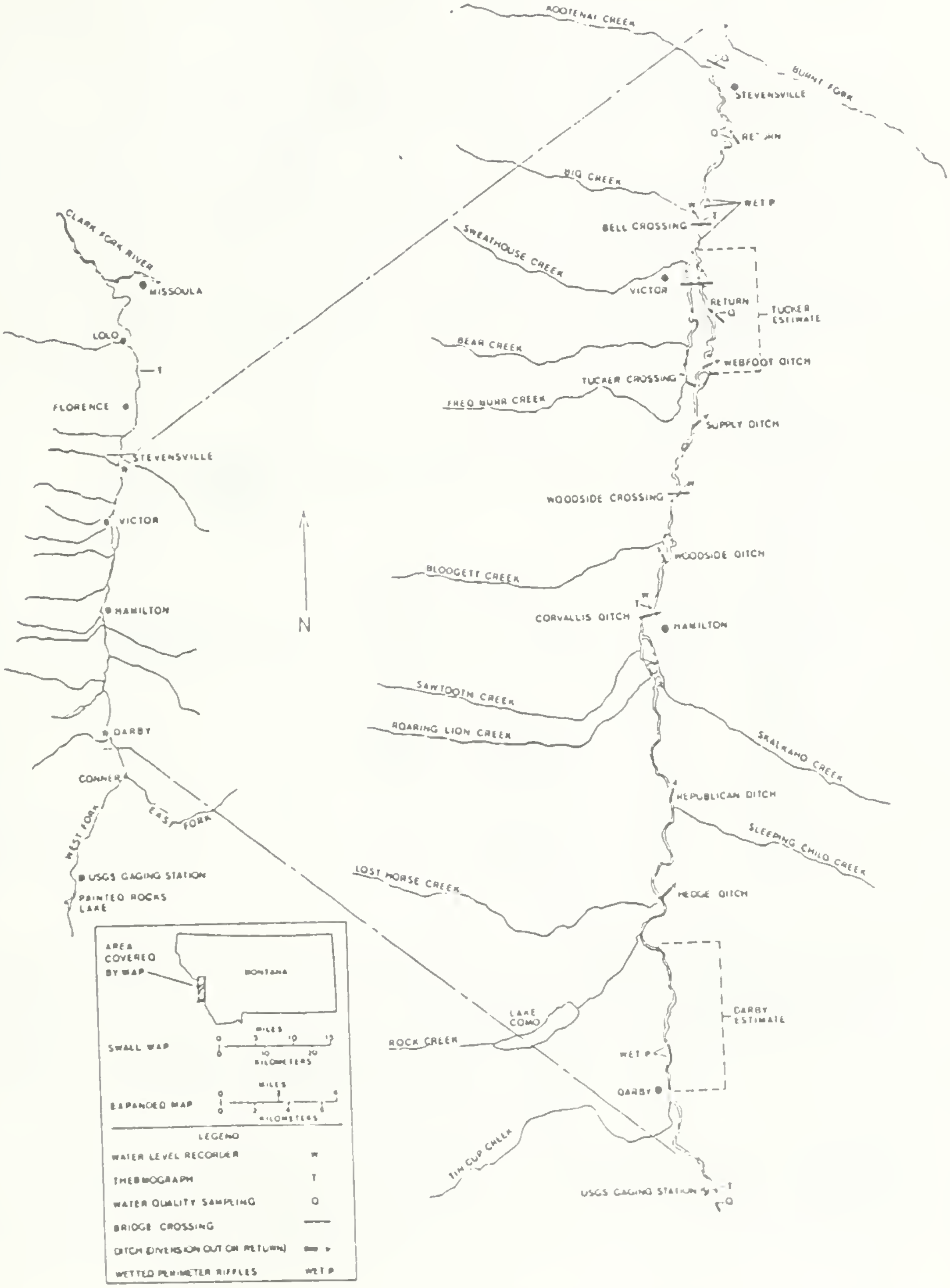

Figure 1. Map of the Bitterroot River showing locations of study sections.

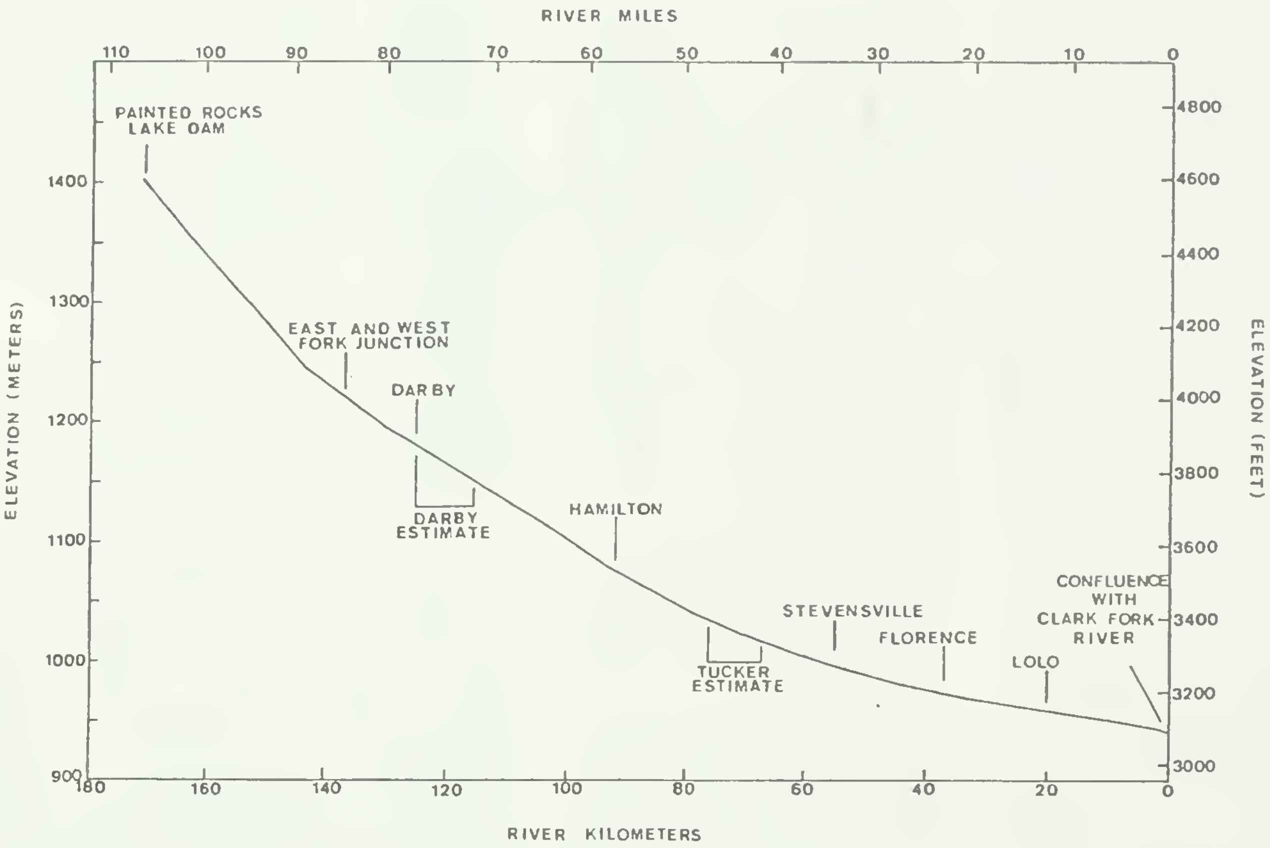

Figure 2. Longitudinal profile of the Bitterroot River from Painted Rocks Reservoir to the confluence with the Clark Fork River.

full pool of 265 hectares (Brown 1982). Elevation at the spillway is 1440 m (4725 ft). As a matter of DNRC policy, flow released from the reservoir is maintained at 3.45 m^3/sec (125 ft^3/sec) during August through November and 2.83 m^3/sec (100 ft^3/sec) during December through July (DNRC 1980). These flow releases do not include spill from the reservoir during spring runoff.

Mean, minimum, and maximum discharges of the Bitterroot River measured near Darby over a 46 year period ending in 1983 were 26.4, 2.0, and 325.7m^3/sec (931, 71 and 11,500 ft^3/sec), respectively (U.S.G.S. 1983). Annual flow of the river at Missoula averages approximately 64.8 m^3/sec (2,289 ft^3/sec). Characteristics of flow monitored at the U.S.G.S. stations established on the West Fork near Painted Rocks Reservoir, the East Fork near Conner and the main stem near Darby have been summarized by Brown (1982). Median values of average monthly flow recorded at these stations during July, August and September are given in Table 1. Flows in the Bitterroot River downstream from the gaging station near Darby vary greatly from reach to reach due to losses from irrigation withdrawals and to gains from tributary inflow and irrigation returns (Figure 1). Critical dewatering of the river commonly occurs in the reach located between Hamilton and Stevensville as a result of irrigation withdrawals.

Table 1. Median values of average monthly flows recorded at stations on the upper Bitterroot River for July, August and September

	West Fork		East Fork		Darby	
Month	m^3/sec	ft^3/sec	m^3/sec	ft^3/sec	m^3/sec	ft^3/sec
July	7.0	247	8.3	293	28.0	990
August	3.8	135	3.1	108	10.4	367
September	3.8	133	2.6	91	8.9	313

Two study sections were established on the Bitterroot River for extensive investigation (Figure 1). The Darby section begins near the bridge at Darby and extends 9.36 km (5.82 mi.) downstream to the Como bridge. This section remains well watered throughout the year and serves as a control.

The Tucker section begins at Tucker crossing and extends downstream 8.92 km (5.54 mi.) to approximately 1.6 km (1 mi.) upstream from Bell crossing. This section is characterized by two channels that become separated by as much as 1.6 km (1 mi.). Because of differences in flow and habitat characteristics, each channel was treated as a distinct reach. The Tucker section was established within the reach of river that historically has become severely dewatered.

METHODS

River Discharge And Groundwater Levels

Stage of the Bitterroot River was monitored using Belfort continuous water level recorders (5-FW series). Recorders installed at Woodside and Bell crossings were mounted on 3 in. (in diameter) standpipes and fastened to bridge abutments. A recorder installed at Hamilton was mounted in a abandoned DNRC gage house above a functional stilling well. Discharge of the river was measured using standard techniques of the U.S.G.S. (Corbett et al. 1943).

Groundwater levels were monitored at three observation wells installed in a line perpendicular to the river at Bell crossing. The three wells were placed at intervals of approximately 2.9, 62.9 and 195.9 m (9.5, 206.3 and 642.8 ft) from the edge of the river. Two of these wells were constructed by pounding 3 in. (in diameter) standard pipe 4.5-6.0 m (15-20 ft.) into the ground. Belfort recorders (5-FW series) were mounted on these two wells. A third well was constructed by pounding a 1 1/4 in. (in diameter) sandpoint approximately 4.5 m (15 ft.) into the ground. Groundwater levels at this well were measured periodically with a tape.

Water Temperature

Thirty-day continuous recording thermographs (Taylor models) were used to monitor water temperatures in the main stem of the Bitterroot River (Figure 1). Two recorders were mounted in gage houses at the U.S.G.S. station near Darby and at the abandoned DNRC station at Hamilton. Two additional recorders were mounted in steel boxes at Bell crossing and McClay bridge. The thermocouple lead for each thermograph was extended through plastic sewer pipe as far as possible into the river.

Water Quality

Analyses of pH, total ammonia and conductivity for water samples collected during 1983 were conducted by the Water Quality Bureau of the Montana State Health Department. Analyses of pH, bicarbonate, total nitrogen, nitrate nitrogen, total phosphorus and conductivity for water samples collected during 1984 were conducted by Dr. Juday at the University of Montana. Analyses of total ammonia for water samples collected during 1984 were conducted by the Water Quality Bureau. Analyses of samples by the Water Quality Bureau were conducted one to three weeks following collection. Analyses of samples by Dr. Juday were conducted within one week following collection. Since analyses are ongoing, procedures used by the Water Quality Bureau and Dr. Juday will be presented in the final report.

Measurements of dissolved oxygen, pH, and total alkalinity were made *in situ* at the time water samples were collected. Concentrations of dissolved oxygen were determined using the azide modification of the Winkler method (APHA, 1976). Analyses of pH were made colorimetrically using methods of the Hach Company. Concentrations of total alkalinity were determined by titration using methods of the Hach Company. Field methods used for analyses of pH and total alkalinity did not meet APHA (1976) standards.

Physical Characteristics Of Study Sections

Physical characteristics of the study sections were measured during August, 1984. Ten equally spaced stations were established within each study section. At each station, four transects were established perpendicular to the stream channel at intervals of 61 m (200 ft.) in a downstream direction. The number of channels containing water at each transect was enumerated. Stream width was measured to the nearest 0.3 m (1 ft.) from water edge to water edge at each transect. Water depth was measured to the nearest 1.5 cm (0.6 in.) at 10 equally spaced intervals along each cross section. The deepest measurement along each transect was considered to be the thalweg of the cross section.

The lengths of a single pool and single riffle within each station were measured by tape. A pool was defined as a portion of the river having reduced water velocities and substantial depths. Pool-riffle periodicity (average distance between the heads of successive riffles divided by the average stream width) and pool-riffle ratio (total length of pools divided by total length of riffles) were determined for each study section using 10 measurements of pool-riffle length. Gradient and section length were determined by measurements taken from U.S.G.S. topographic maps.

The total area of potential overhanging and instream cover was measured within 1.5 m (5 ft.) on either side of each transect. Cover was classified as either brush, debris, undercuts or rock shelves. Only features which were within the water or $\leq$ 0.6 m (2 ft.) above the surface were considered cover. Depth of the water beneath these features had to be greater than 15 cm (6 in.).

Parameters Of Salmonid Populations

A mobile electrofishing system was used to sample salmonid populations in the Bitterroot River. A 4.0 m (13 ft.) fiberglass boat with negative electrodes suspended from the gunwales was used to carry a portable 2000 watt generator and a Coffelt (Model VVP-2E) rectifying unit. The positive electrode was hand held and attached with approximately 10 m (30 ft.) of electrical cord.

Captured salmonids were classified by species, measured to the nearest 1.0 mm (total length) and weighed to the nearest 10 grams. Selected samples of trout were tagged with individually numbered Floy tags. Multiple marking and recapture runs were necessary to obtain adequate samples for population estimates. A caudal fin punch was used to mark the fish. Samples of scales were taken for analyses of age and growth. All fish were released near their site of capture. Recapture runs were made approximately 2 weeks following marking runs.

Population estimates of salmonids were made using Chapman's modification of Peterson's mark and recapture formula (Ricker 1975). A computer program developed by the Montana Department of Fish, Wildlife and Parks was used to calculate estimates of populations, condition factors for fish over 12.6 cm (5 in.) in total length, and corresponding 80% confidence intervals. Estimates of numbers and biomass were made by length and age groups. Condition factors were computed using the formula (Carlander 1969):

$$k = \frac{10^5 w}{l^3}$$

where k = condition factor,
w = total weight (gm) and
l = total length (mm).

The Monastyrsky method (Tesch, 1971) was used to back-calculate lengths at age of fish:

$$\text{Predicted length} = k \times (\text{scale measurement})^n$$

where k = intercept on the ordinate and

n= slope of the relationship.

Spawning of trout was monitored by determining the sexual maturity of captured trout, observing the distribution of spawners, and searching for redd sites. Adult trout captured during the spawning season were classified as either ripe (exuding sexual products), gravid (females with distended abdomens containing eggs), spent (males or females exhibiting secondary sexual characteristics and collapsed abdomens), or not ripe (not exhibiting any of the above characteristics).

Values for water velocity and depth at redd sites were measured at the upstream edge of the pit. The surface area of redds was determined by using the formula (Reiser and Wesche 1981):

$$\text{Area} = (1/2\ L \times W_1) + (1/2\ L \times W_2) + (1/6\ L \times W_3)$$

Where L = length of redd (m),
W_1 = width across lower third (m),
W_2 = width across mid section (m) and
W_3 = width across upper third (m).

Minimum Flow Recommendations

A wetted perimeter/inflection point method was used to quantify instream flow needs of trout. In general, this technique derives wetted perimeter-discharge relationships at selected channel cross sections using a computer model. A graphical plotting of these relationships typically delineates an inflection point. At this point, the rate of loss of wetted perimeter greatly increases as discharge decreases. Nelson (1980) found standing crops of adult trout substantially decreased as flows decreased below derived inflection points. A detailed description of the rationale and methodology for the wetted perimeter method has been given by Nelson (1983).

Statistical Analyses

Analysis of variance was used to compare the data on the physical characteristics of the study sections. Sample means were compared using the least significant difference technique when analysis of variance indicated differences among sections. Linear regression analyses were used to determine the relationship between stage and discharge of the river. Significant differences and correlations were those in which the probability of obtaining the same results by chance was less than 0.05 ($p<0.05$). Differences in trout densities between study sections were considered insignificant when 80% confidence intervals overlapped.

RESULTS

Bitterroot River Discharge

Discharge in 1983

Discharge of the Bitterroot River was monitored during 1983 from stations established at Woodside and Bell crossings (Figure 1). Discharge at Woodside crossing was monitored from August 29 through November 15 using a continuous water level recorder. At Bell crossing, discharge was monitored by staff gage readings from July 13 through August 28 and by using a continuous water level recorder from August 29 through November 12. Rating curves of stage-discharge relationships for the staff gage at Bell crossing and the water level recorders at Woodside and Bell crossings are shown in Appendix Figures 4-6. The least squares fit of log stage versus log discharge was determined to be significant for each rating curve ($r=0.99$, $p\leq 0.01$).

Hydrographs derived during 1983 from the Woodside and Bell stations are shown in Figure 3. Included in this figure are hydrographs derived from the U.S.G.S. stations on the West Fork near Painted Rocks Reservoir and on the main stem near Darby. Mean daily flows (24 hour averages) obtained from the Darby, Woodside and Bell stations are given in Appendix Table 1.

Discharge at the Darby and Bell stations progressively decreased from early July through mid August. From mid August through mid September, flows passing stations on the main stem fluctuated from 10.4 m^3/sec (367 ft^3/sec) to 17.1 m^3/sec (603 ft^3/sec). These fluctuations were likely due to a series of rainfall events. Discharge at the Woodside and Bell stations progressively increased from mid September through mid November. In contrast, flows at the Darby station remained relatively stable through this monitoring period. Increases in flow at the Woodside and Bell stations were probably due to closure of irrigation diversions on the tributaries and on the main stem.

During 1983, summer discharge was considerably greater than median daily values derived at the U.S.G.S. station near Darby (Figure 4). The release of supplemental water from Painted Rocks Reservoir and wetter than normal weather conditions contributed to the occurrence of these greater flows. Monthly rainfall measured at a station near Hamilton averaged 2.77 cm (1.1 in.) greater than normal during July, August and September (U.S. Dept. of Commerce 1983). Supplemental water was released from Painted Rocks Reservoir at a rate of 2.83 m^3/sec (100 ft^3/sec) for the periods of August 9 to September 9 and September 13 to October 28. The quantity of additional water released from the reservoir during 1983 totaled 14,476 acre feet.

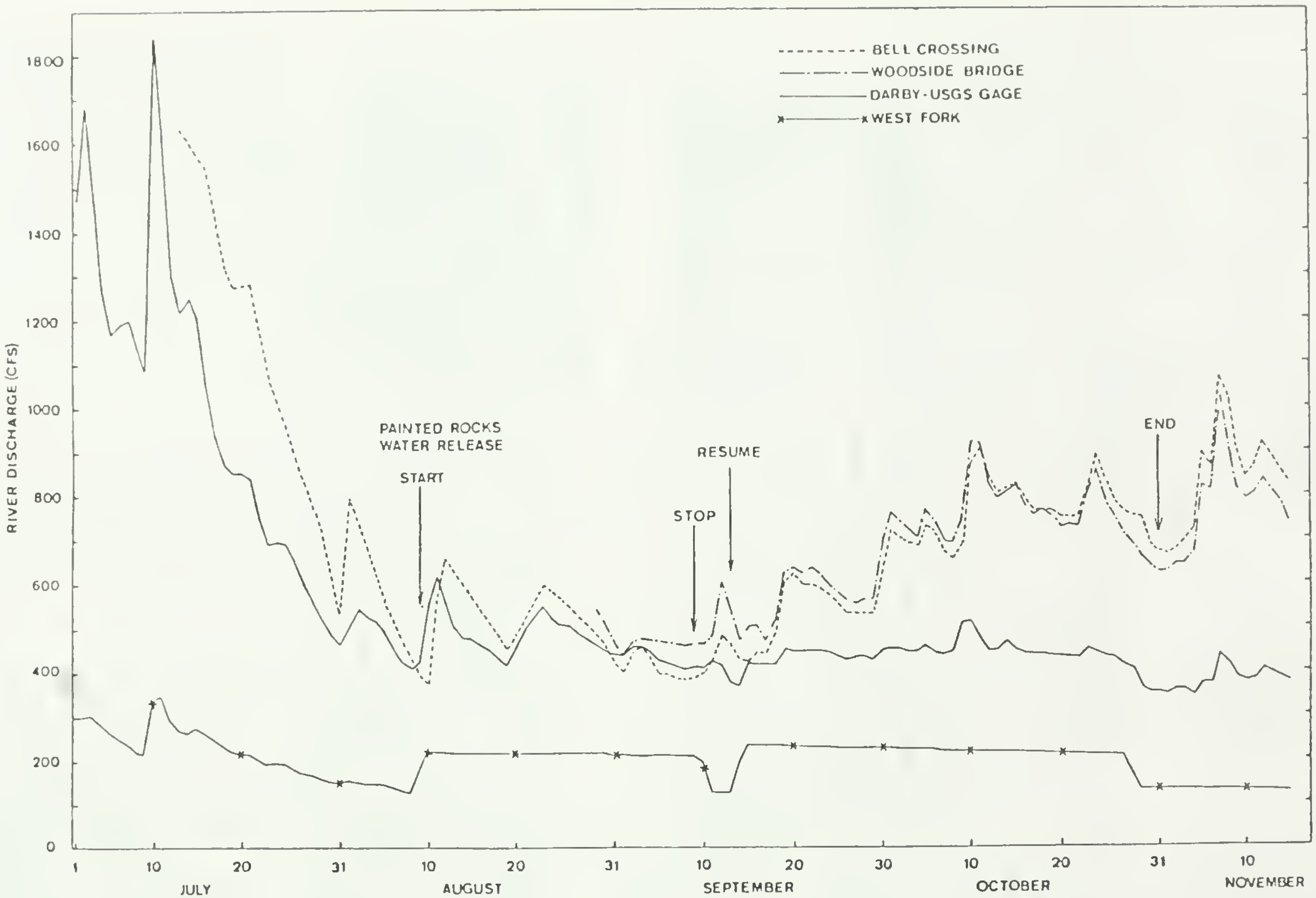

Figure 3. Hydrographs derived from the West Fork, Darby, Woodside, and Bell stations on the Bitterroot River during 1983.

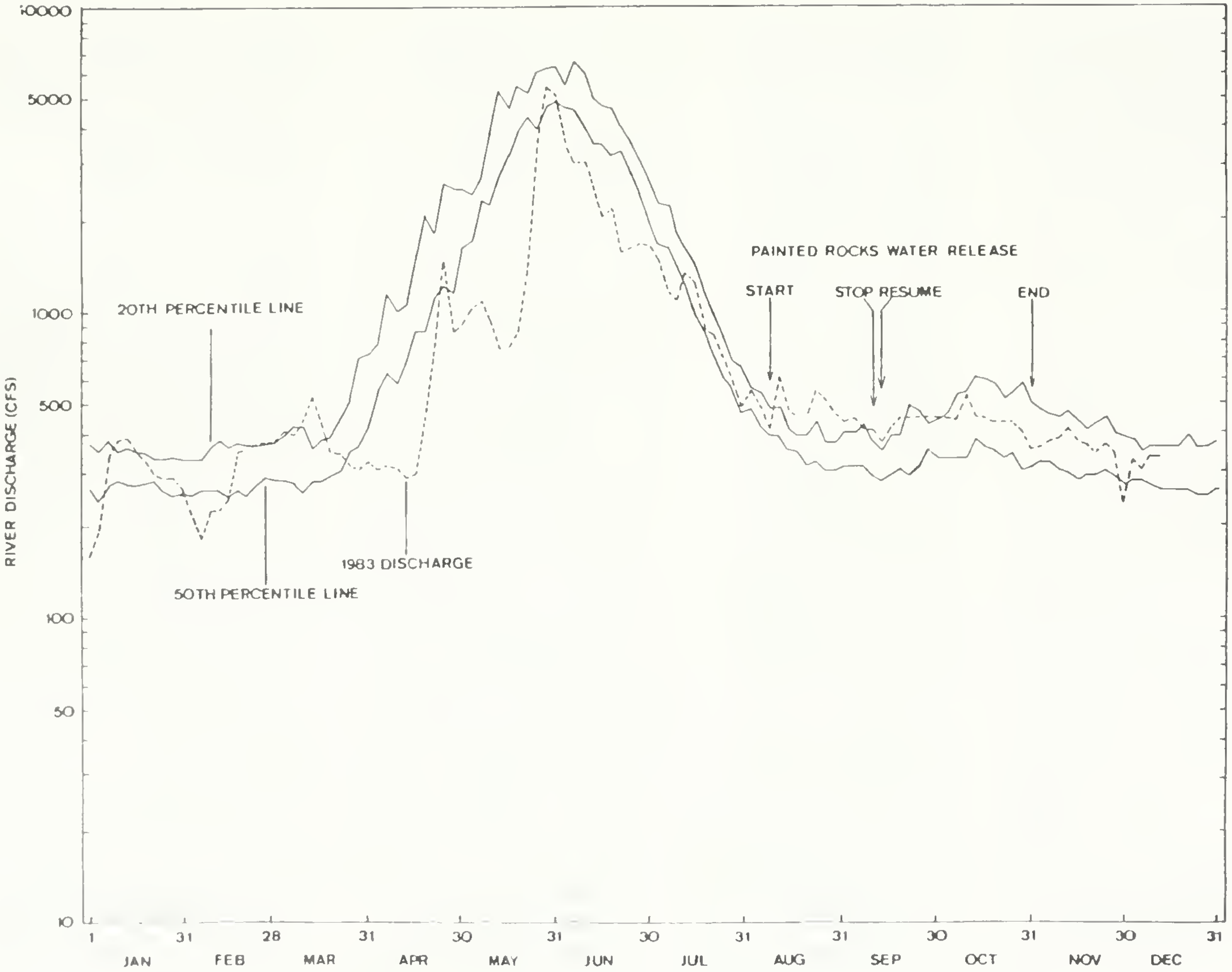

Figure 4. Comparison of 1983 flows to duration hydrographs derived for 20 and 50% exceedence values at the U.S.G.S. station near Darby.

Discharge in 1984

During 1984, discharge of the Bitterroot River was monitored using continuous water level recorders installed at Hamilton, Woodside crossing and Bell crossing. Discharge at Hamilton was monitored from August 10 through October 15. At Woodside and Bell crossings, discharge was monitored from early July through October 15. Discharge at these stations will continue to be monitored through the end of November. Stage-discharge rating curves derived for the three stations are shown in Appendix Figures 7-9. The least squares fit of log stage versus log discharge was significant for each rating curve ($r=0.99$ $p\leq 0.01$). New rating curves were developed at the Woodside and Bell stations during 1984 because changes in channel configuration occurred at each site during spring runoff.

Hydrographs derived during 1984 from the Hamilton, Woodside and Bell stations are presented in Figure 5. Included in this figure are hydrographs derived from the U.S.G.S. stations located near Painted Rocks Reservoir and Darby. Mean daily flows (24 hour averages) obtained from the Darby, Hamilton, Woodside and Bell stations are given in Appendix Table 2. Minimum flows recorded at the respective stations were 12.1, 10.6, 10.4, and 8.8 m^3/sec (427, 373, 368, and 311 ft^3/sec). These minimum flows were achieved during August.

Flows monitored from the main stem stations progressively decreased from early July through late August and substantially increased during early September. Increases in discharge were apparently due to an increase in precipitation and a reduction in irrigation withdrawals. During September, discharge at the Hamilton, Woodside and Bell stations exhibited large fluctuations. These fluctuations were probably caused by individual precipitation events. Fluctuations in flow were smaller at the Darby station since fewer tributaries contribute to inflow above this site than at downstream stations. Discharge progressively decreased at the main stem stations from September through mid October.

Discharge during the summer of 1984 was greater than median daily valves derived at the U.S.G.S. gage station near Darby (Figure 6). Again, the release of supplemental water from Painted Rocks Reservoir contributed to the occurrence of these greater flows. Releases of additional water during 1984 were based on a schedule described in the draft water management plan (Lere 1984). A test spill of 5.66 m^3/sec (200 ft^3/sec) was released during August 11-16. From August 18 to September 19, supplemental water was released at a rate of 4.25 m^3/sec (150 ft^3/sec). Beginning September 20, supplemental water was released at a rate of 2.12 m^3/sec (75 ft^3/sec). The release of additional water ended on October 7. The resultant quantity of supplemental water released from the reservoir during 1984 totaled 14,269 acre feet.

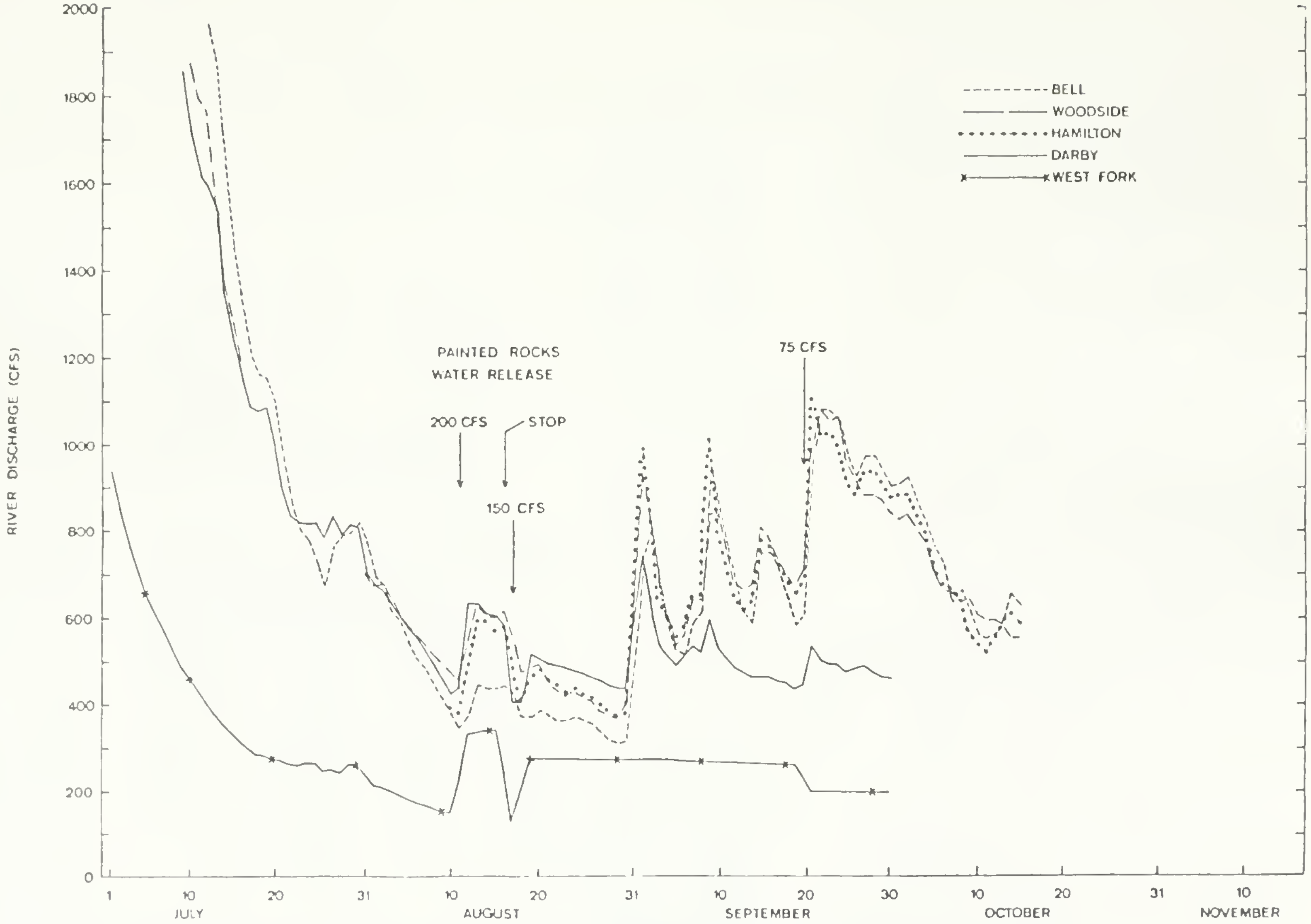

Figure 5. Hydrographs derived from the West Fork, Darby, Hamilton, Woodside, and Bell stations of the Bitterroot River during 1984.

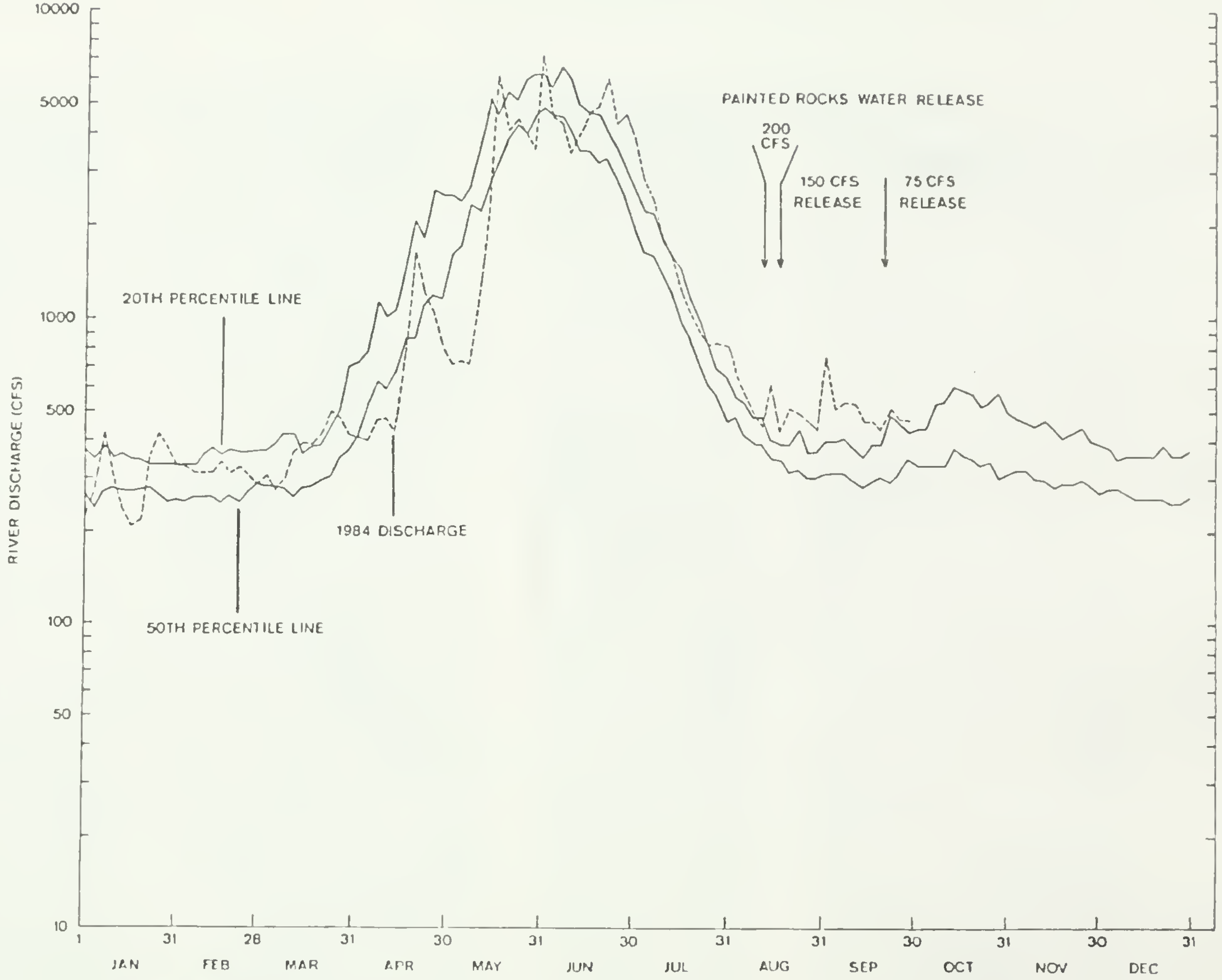

Figure 6. Comparison of 1984 flows to duration hydrographs derived for 20 and 50% exceedence values at the U.S.G.S. station near Darby.

Flow relationships

Flow relationships among the main stem stations varied annually and seasonally. These relationships were dependent upon rainfall events and the timing and duration of the irrigation season. Inflow from precipitation events and outflow from irrigation withdrawals affected discharge to a greater extent at the Woodside and Bell stations than at the Darby station due to the additive effects of diversions and tributaries in a downstream direction. The effects of supplemental water releases on discharge also varied among stations. Due to the complexity of the basin, flow routing models that have been developed are relatively inaccurate. Flow relationships among reaches of river are better defined by monitoring discharge at strategic stations for a substantial period of time. Flow relationships and the development of a routing model are discussed in detail in the draft water management plan (Lere 1984).

Assessment of Bank Storage

The effect of bank storage and groundwater on discharge of the Bitterroot River was evaluated during 1983 using two simultaneous methods. In the first method, a water balance equation was derived where data were obtained to solve for the bank storage variable. Data were gathered in the reach of river between Woodside and Bell crossings. The equation derived for the water balance was:

$\Delta S_t = (I_t + T_t) - (O_t + D_t)$ where

ΔS_t = volume of water released from bank storage plus groundwater inflow over time (t),

I_t = volume of inflow from the Bitterroot River at Woodside crossing over time (t),

T_t = volume of inflow from tributaries and returns between Woodside and Bell crossings over time (t),

O_t = volume of outflow from the Bitterroot River at Bell crossing over time (t) and,

D_t = volume of outflow from diversions between Woodside and Bell crossings over time (t).

A 72 hour period between August 29 and September 1 was chosen for assessment. Water was expected to be released from bank storage during this period because discharge of the river decreased about 2.83 m^3/sec (100 ft^3/sec) over the 72 hours. Flows from tributaries, returns and diversions within the study reach were measured between August 29 and September 9. Inflow from tributaries and returns totaled 3.98 m^3/sec (141 ft^3/sec) and outflow from diversions totaled 5.90 m^3/sec (208 ft^3/sec). Flows of tributaries, returns and diversions were assumed to remain constant. For the 72 hour period, inflow of the Bitterroot River at Woodside crossing averaged 13.59 m^3/sec (480 ft^3/sec) and outflow of the river at Bell crossing averaged 12.29 m^3/sec (434 ft^3/sec). Solving for $\triangle S_{72}$ (change in bank storage over 72 hours) with terms in acre feet:

$$\triangle S_{72} = (2855.9 + 836.3)_{72} - (2583.1 + 1238.9)_{72}$$

$$\triangle S_{72} = -129.78 \text{ acre feet}$$

$$\text{or} \quad \triangle S_{72} = -0.61 m^3/\text{sec} \ (-21.63 ft^3/\text{sec}) \text{ for 72 hours.}$$

By this method, bank storage/groundwater inflow contributed approximately 0.61 m^3/sec (21.63 ft^3/sec) to the discharge of the Bitterroot River between Woodside and Bell crossings during the 72 hours.

For the second method, three observation wells were installed near Bell crossing to monitor fluctuations in groundwater levels in relation to changes in river discharge. The fluctuation in groundwater levels were closely correlated with changes in river discharge, with groundwater levels lagging approximately one hour behind discharge (Figure 7). Groundwater levels observed in the well nearest the river were consistantly lower than surface water elevations. This phenomenon was unexpected and was possibly due to groundwater flowing parallel with river flows (Dr. Woessner, personal communication).

The period chosen for assessment corresponded to the 72 hour period used for the water balance method. Water level fluctuations observed over this time period are shown graphically in Figure 8. Changes in groundwater levels diminished with distance from the edge of the river. Theoretically, inflow of bank storage into the river equalled the water lost from the change in the elevation of water levels recorded between August 29 and September 1. The change in water level elevations formed a shape similar to a wedge. The volume of water released from bank storage was calculated by computing the area of this wedge and multiplying by the length of the study reach. A specific yield value was then applied to this computed volume to obtain the quantity of water released from bank storage. Assumptions made for the purpose of computation were:

1. Groundwater levels fluctuated uniformly between Woodside and Bell crossings.

2. Groundwater levels fluctuated uniformly on the east and west sides of the river.

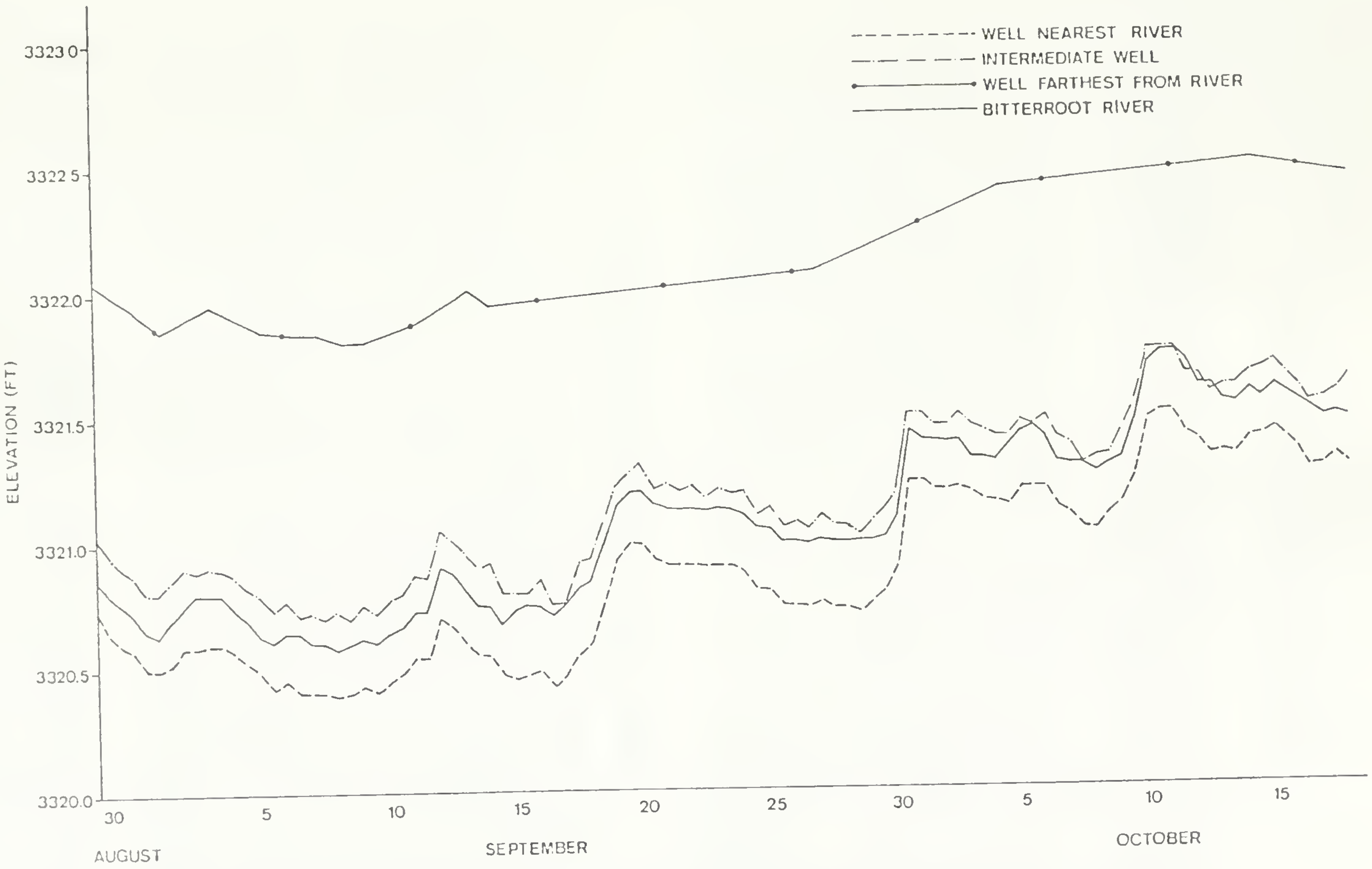

Figure 7. Elevation of groundwater levels measured from three observation wells at Bell Crossing during 1983.

3. Specific yield (amount of water yielded by an aquifer) averaged 0.20 for the area of concern.

By this approach, the calculated volume of water released from bank storage in the reach of river between Woodside and Bell crossings totalled 123.72 acre feet or 0.58 m^3/sec (20.6 ft^3/sec) over the 72 hour period. This volume is similar to 129.8 acre feet computed from the water balance equation.

Assessments from both methods indicated inflow from bank storage did not contribute significant quantities of water to discharge in the Bitterroot River. In support of this conclusion, a flow routing model for the Bitterroot River derived by the U.S.G.S. indicated the effect of bank storage releases on discharge was relatively insignificant (Parrett 1984). However, an unpublished base flow study by the U.S.G.S. determined discharge in the Bitterroot River between Hamilton and Bell crossing gained 5.61 m^3/sec (198 ft^3/sec) from inflow of groundwater (U.S.G.S. 1970; cited in Senger 1973). These contrasting data indicate the effects of bank storage and groundwater on discharge in the Bitterroot River are complex and poorly understood. A significantly greater effort would be required to fully quantify these relationships.

Test releases from Painted Rocks Reservoir

Supplemental water released into the Bitterroot River may become depleted as a result of natural phenomena (infiltration, evapotranspiration) or by withdrawals from main stem irrigation systems. Two test spills from the reservoir were conducted during April and August, 1984 to determine the extent of these depletions. During April, an additional 5.66 m^3/sec (200 ft^3/sec) was released from the reservoir for a period of 47 hours. The U.S.G.S. station located on the West Fork was used to monitor this test release. Changes in flow in the Bitterroot River were monitored using the U.S.G.S. gage near Darby and a water level recorder at Bell crossing. Results of this release are shown graphically in Figure 9. Approximately 794 acre feet of supplemental water was released during the test. This block of additional water took 8 hours to reach the Darby station and 24.5 hours to reach the Bell station. About 18% of the supplemental water was lost before reaching the Darby station and about 63% was lost before passing Bell crossing.

During August, an additional 5.66 m^3/sec (200 ft^3/sec) was released from the reservoir for a period of 117 hours. Again, the U.S.G.S. station located on the West Fork was used to monitor this test release. Changes in flow in the Bitterroot River were monitored using the U.S.G.S. gage near Darby and water level recorders at Hamilton, Woodside crossing and Bell crossing. Results

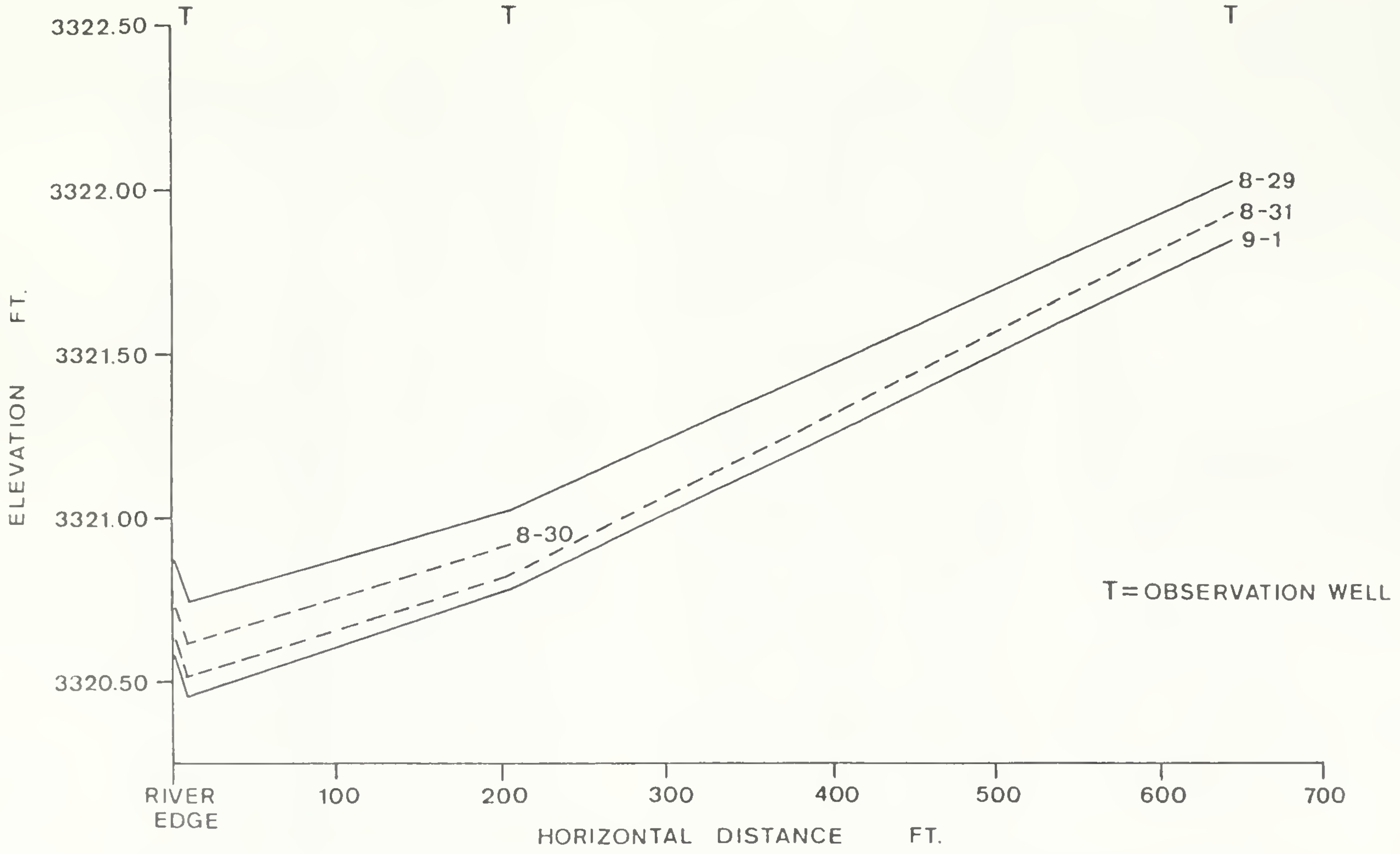

Figure 8. Elevations of groundwater levels measured from three observation wells at Bell crossing during the period from August 29 to September 1, 1983.

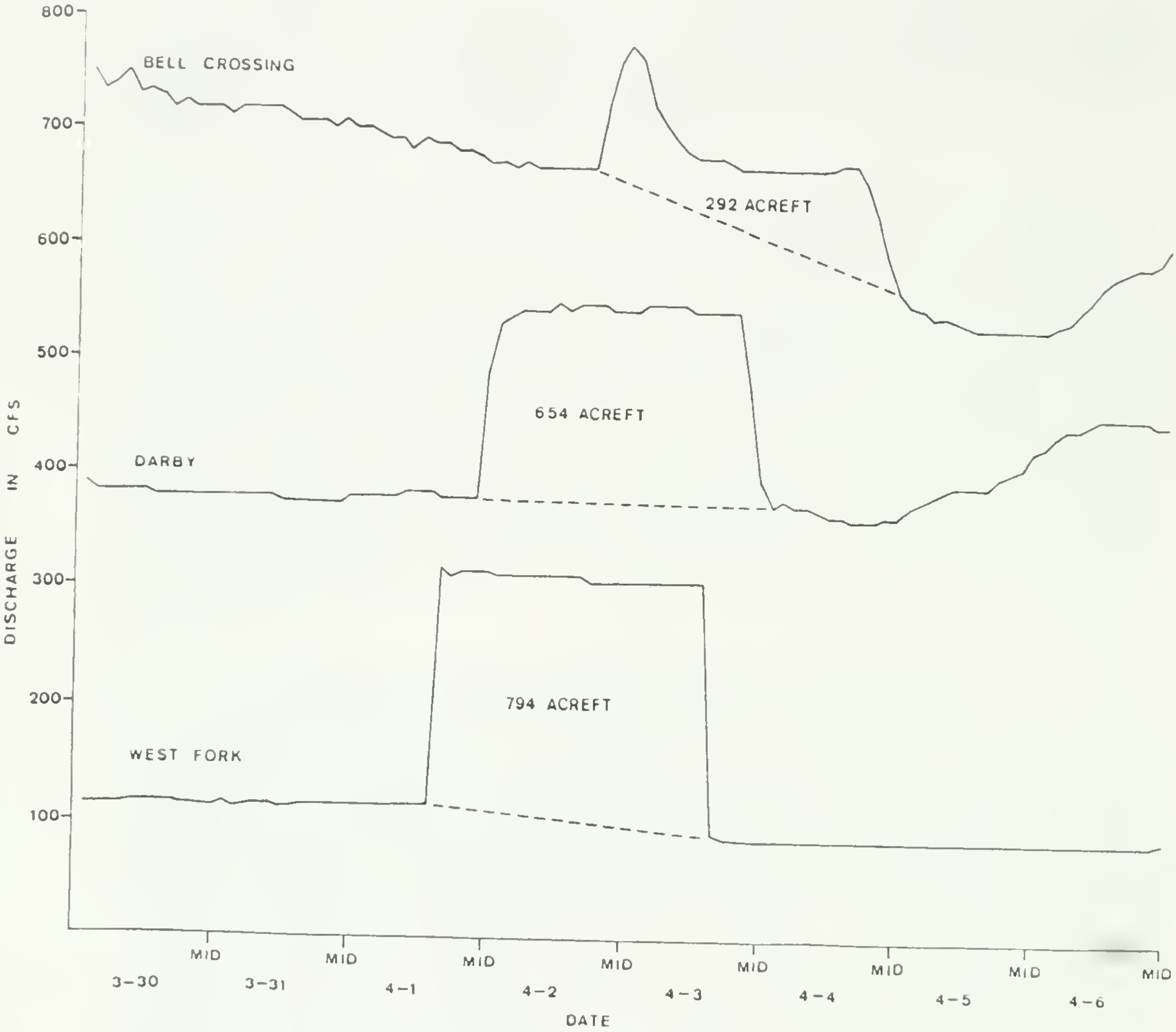

Figure 9. Hydrographs derived from the West Fork, Darby, and Bell crossing stations during a test release of water from Painted Rocks Reservoir conducted in April, 1984.

of this release are shown graphically in Figures 10 and 11. Approximately 1,913 acre feet of supplemental water were released from the reservoir during this test. This block of additional water took about 8, 17, 18 and 24 hours, respectively, to reach the Darby, Hamilton, Woodside, and Bell stations. Approximately 24% of the supplemental water was lost before reaching the Darby station. About 78% of the original release was estimated to reach the Hamilton station. Gains in river discharge from tributary inflow were apparently equal to losses from irrigation withdrawals and natural causes between the Darby and Hamilton stations. Approximately 33% of the original release was lost before reaching Woodside crossing. The greatest depletion of the supplemental block of water occurred between Woodside and Bell crossings. Only 37% of the original release passed the Bell station.

The loss of supplemental water from irrigation withdrawals could not be separated from losses due to natural causes. A majority of the water lost between the reservoir and the Darby station is probably due to natural phenomena since only a few minor diversions and pumping sites remove water between these two stations. In contrast, a majority of the water lost between Woodside and Bell crossings is probably due to irrigation withdrawals since two major diversions and numerous minor canals remove substantial quantities of water between these two stations. These data support the need to monitor flows in the dewatered reach of the river to assure supplemental water would remain instream. The major diversions on the river also would need to be monitored to assure that withdrawals do not exceed the appropriation rights for each ditch system.

Reservoir Drafting

The elevation of the water level in Painted Rocks Reservoir was monitored periodically from August 10 through October 29, 1984 to monitor the effects of accelerated drafting. Elevations of the reservoir level measured during 1984 are presented in Table 2. The level of the reservoir, following spring runoff, remained above or at full pool through mid August. From mid August through the end of October the reservoir was steadily drawn down. The elevation of the reservoir level on October 29 was 10.1m (33.22 ft.) below the elevation of the spillway. Approximately 15,200 acre feet of water remained in storage on this date. The median value for storage contents at the end of October is about 21,275 acre feet (Brown 1982). The release of an additional 14,000 acre feet from the reservoir during 1984 apparently drafted the reservoir to a greater than normal extent. End of month contents for August, September and October were less than median values given by Brown (1982).

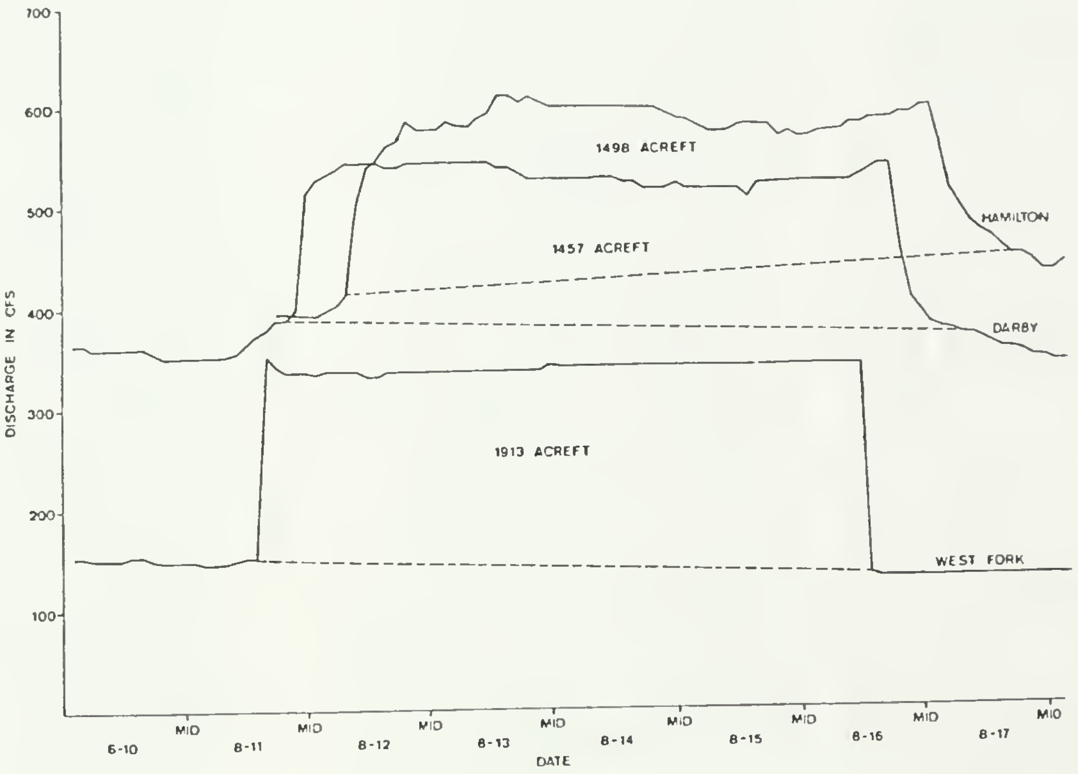

Figure 10. Hydrographs derived from the West Fork, Darby and Hamilton stations during a test release of water from Painted Rocks Reservoir conducted in August, 1984.

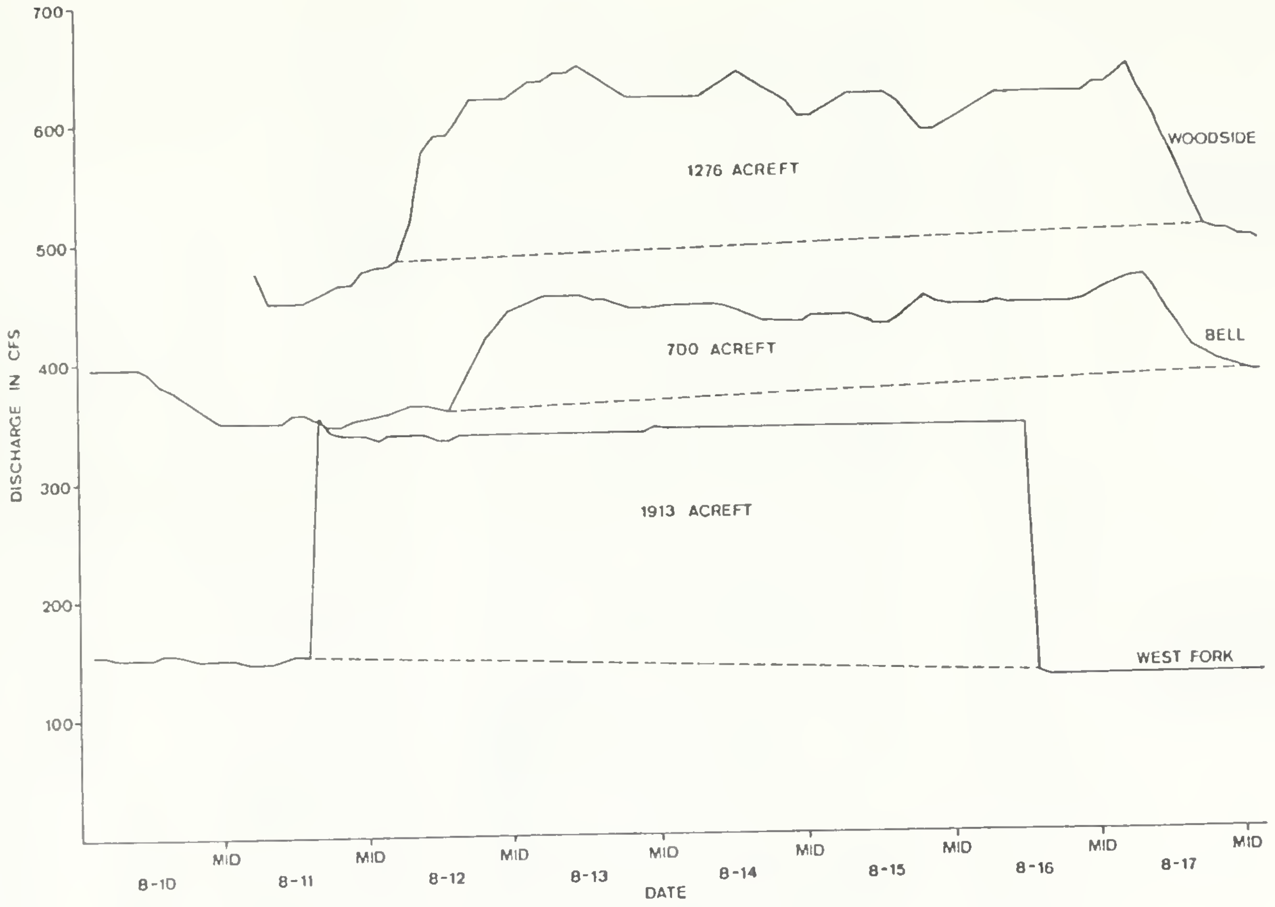

Figure 11. Hydrographs derived from the West Fork, Bell crossing and Woodside crossing stations during a test release of water from Painted Rocks Reservoir in August, 1984.

Table 2. Water level elevations and associated storage measured in Painted Rocks Reservoir during 1984.

Date	Elevation (ft.)	Storage (Acre-Feet)[2]
8-10-84	4,725.48'[1]	32,362
9- 4-84	4,713.37	25,000
9-19-84	4,703.93	20,300
9-26-84	4,701.05	18,800
10-16-84	4,696.06	16,800
10-29-84	4,692.26	15,200

[1] Elevation of spillway is 4,725.30 ft.

[2] Obtained from storage rating curve given by Brown (1982)

The effects of reservoir draw down on boat launching was monitored at three public sites (Figure 12). At the campground on Little Boulder Creek, the boat ramp became unusable due to draw down by mid September. On October 29, the distance from the top of the ramp to waters edge was approximately 84 m (276 ft.). Launching of boats from the Slate Creek campground became difficult during mid September due to the exposure of a mudflat. Boats are launched from a gravel beach at this campground. On October 29, the distance from the gravel beach to waters edge was about 350m (1,148 ft). The boat ramp at the state recreation area became unusable by early September. An extensive mudflat was exposed at this site due to drafting of the reservoir. The distance from the bottom of the boat ramp to waters edge on October 29 was approximately 692 m (2,271 ft).

Recreational use of Painted Rocks Reservoir appeared to decline during September. This decline was probably due to the loss of boat launching facilities and to cooler weather conditions. An extension of the boat ramp at the campground on Little Boulder Creek could delay the loss of launching facilities due to accelerated drawdown of the reservoir.

Water Temperature

West Fork of Bitterroot River

Water temperatures in the West Fork of the Bitterroot River were monitored near the base of Painted Rocks Reservoir during August 26 to December 5, 1983 and during March 19 to October 29, 1984. Recordings from a maximum/minimum thermometer and individual observations are presented in Figure 13. Water temperatures ranged

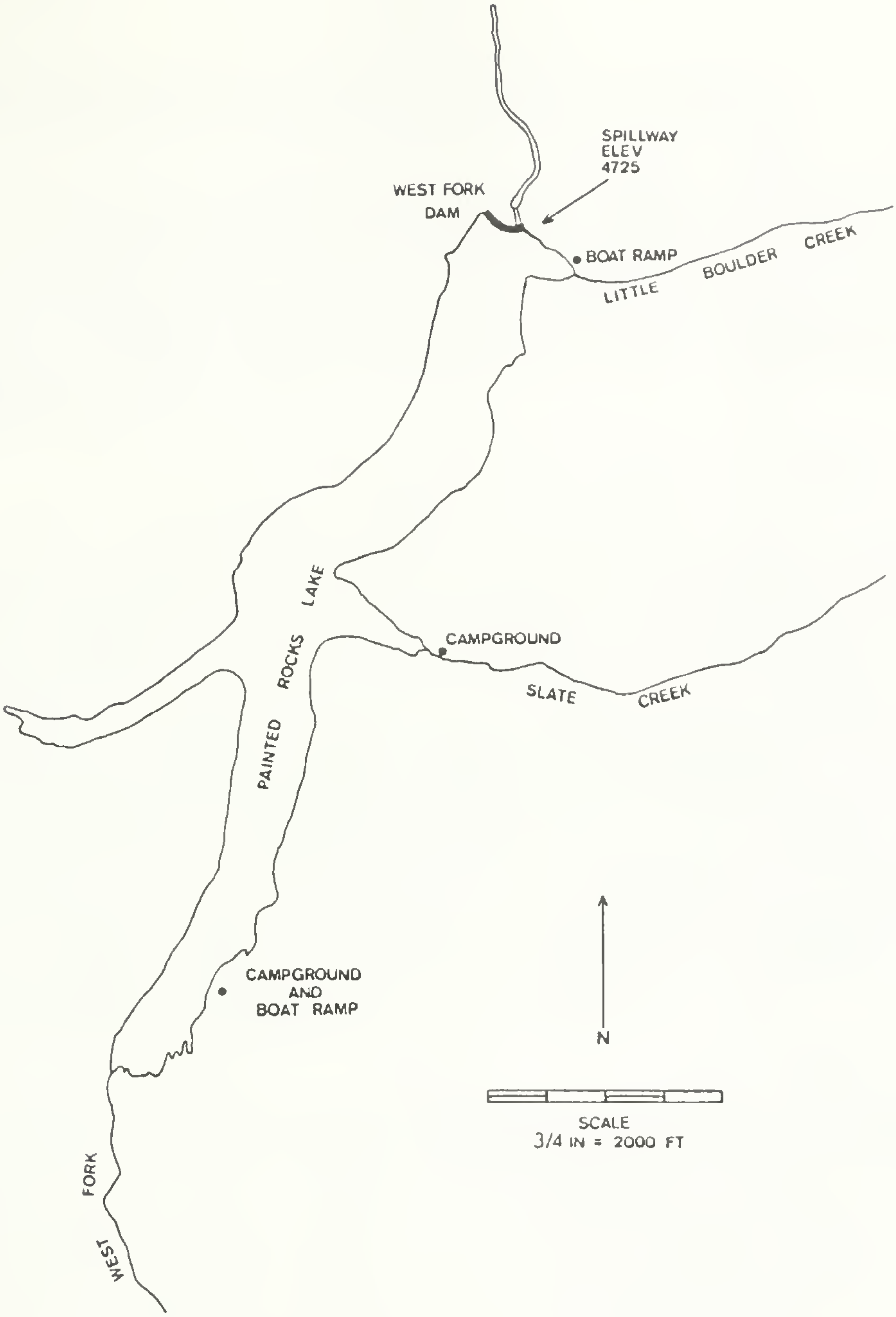

Figure 12. Map of Painted Rocks Reservoir showing campgrounds and boat launching facilities.

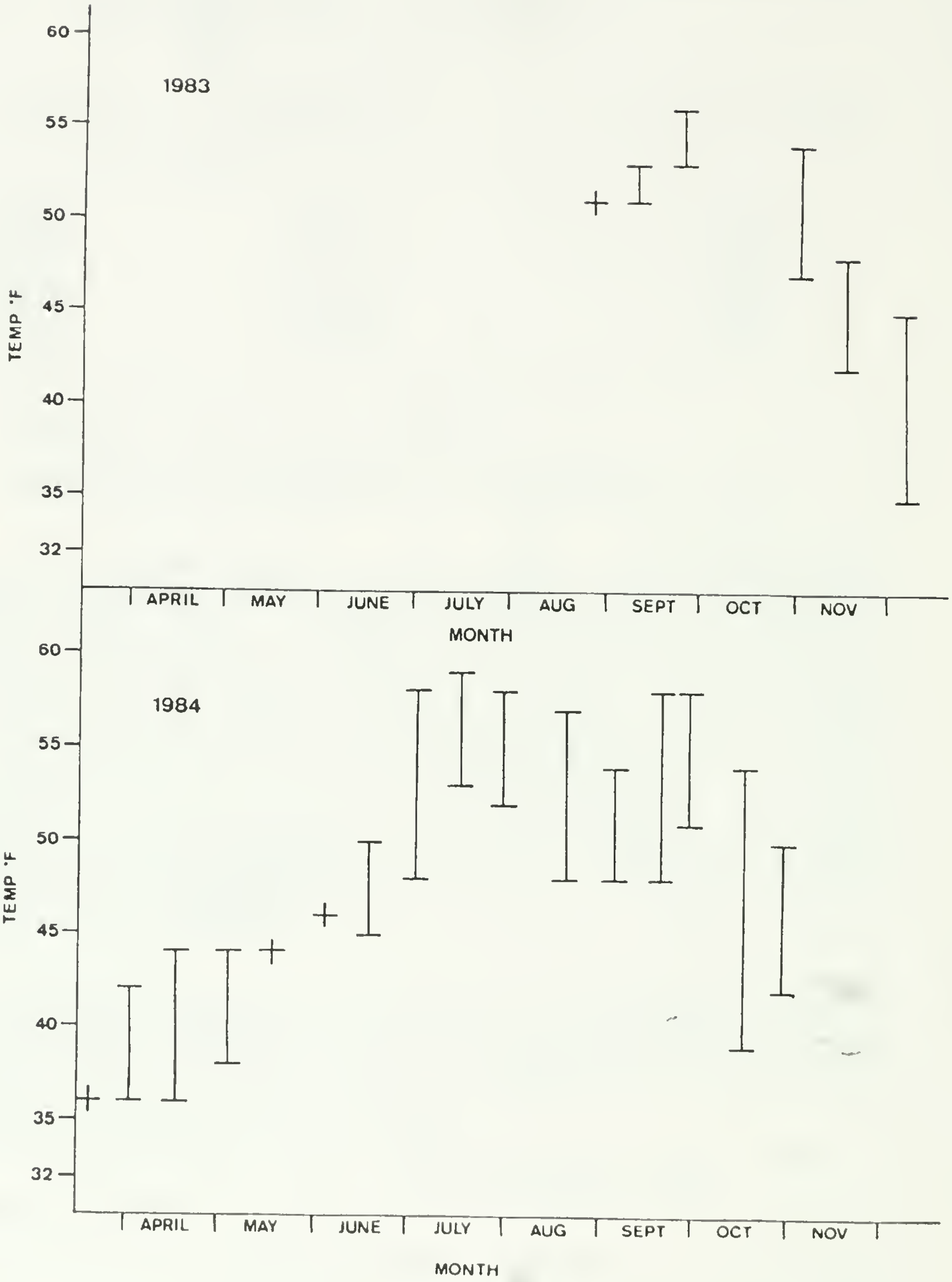

Figure 13. Water temperatures monitored in the West Fork of the Bitterroot River near Painted Rocks Reservoir during 1983 and 1984. Bars represent maximum/ minimum thermometer readings. Plus signs represent individual thermometer readings.

from 1.7 to 13.3C (35 to 56F) during 1983. Temperatures recorded in 1983 exhibited a cooling trend beginning in October.

In 1984, water temperatures ranged from 2.2 to 15.0C (36 to 59F). Water temperatures warmed progressively through July and began to cool during October. The maximum temperature was reached during the first half of July. Water temperatures did not appear to be significantly affected by the release of additional water from the reservoir. Spot observations indicated water temperatures decreased approximately 1.1C (2.0F) upon the release of supplemental water.

Main stem of the Bitterroot River

Water temperatures in the Bitterroot River were monitored during the first week in March to the end of September, 1984 at stations established near Darby, Hamilton, Bell crossing and McClay bridge (Figure 1). Water temperatures monitored at each station progressively warmed from March through late July or early August (Figures 14 and 15). In addition, maximum daily temperatures measured at successive stations warmed in a downstream direction to Bell crossing. Maximum daily temperatures recorded at the Bell and McClay stations, however, remained similar through the monitoring period. Cooler tributary inflow between these stations may have prevented further warming of the river. Daily maximum temperatures averaged 11.0, 12.5, 13.9 and 13.6C (51.9, 54.5, 57.0, and 56.5F) at the Darby, Hamilton, Bell and McClay stations, respectively. The release of supplemental water from Painted Rocks Reservoir during 1984 did not appear to significantly affect water temperatures in the river.

Daily maximum and minimum temperatures recorded in the river at the 4 stations are presented in Appendix Tables 3-6. Maximum water temperatures recorded at the Darby, Hamilton, Bell and McClay stations were 20.3, 21.6, 22.2 and 21.6C (68.5, 71.0, 72.0 and 71.0F), respectively. These temperatures were recorded at each station during July 25 or 26. Diel fluctuations of water temperature averaged 3.66, 3.61, 3.44, and 2.00C (6.6, 6.5, 6.2 and 3.6F), respectively, at the Darby, Hamilton, Bell, and McClay stations. Statistical comparisons of water temperature among stations will be presented in the final report. Water temperatures will continue to be monitored through November, 1984.

Water temperatures that are greater than 17-20C (63-68F) have been shown to exceed the physiological optimum for growth in salmonids (Brett et al. 1969, Brockson and Bugge 1974). Temperatures exceeded 19.4C (67F) on 2, 22, 30 and 40 days, respectively, at the Darby, Hamilton, Bell and McClay stations. These data indicate water temperatures upstream from Darby were probably optimal for trout survival in 1984. Downstream from Hamilton, temperatures recorded in the river during 1984 were somewhat less than optimal for trout. However, temperatures re-

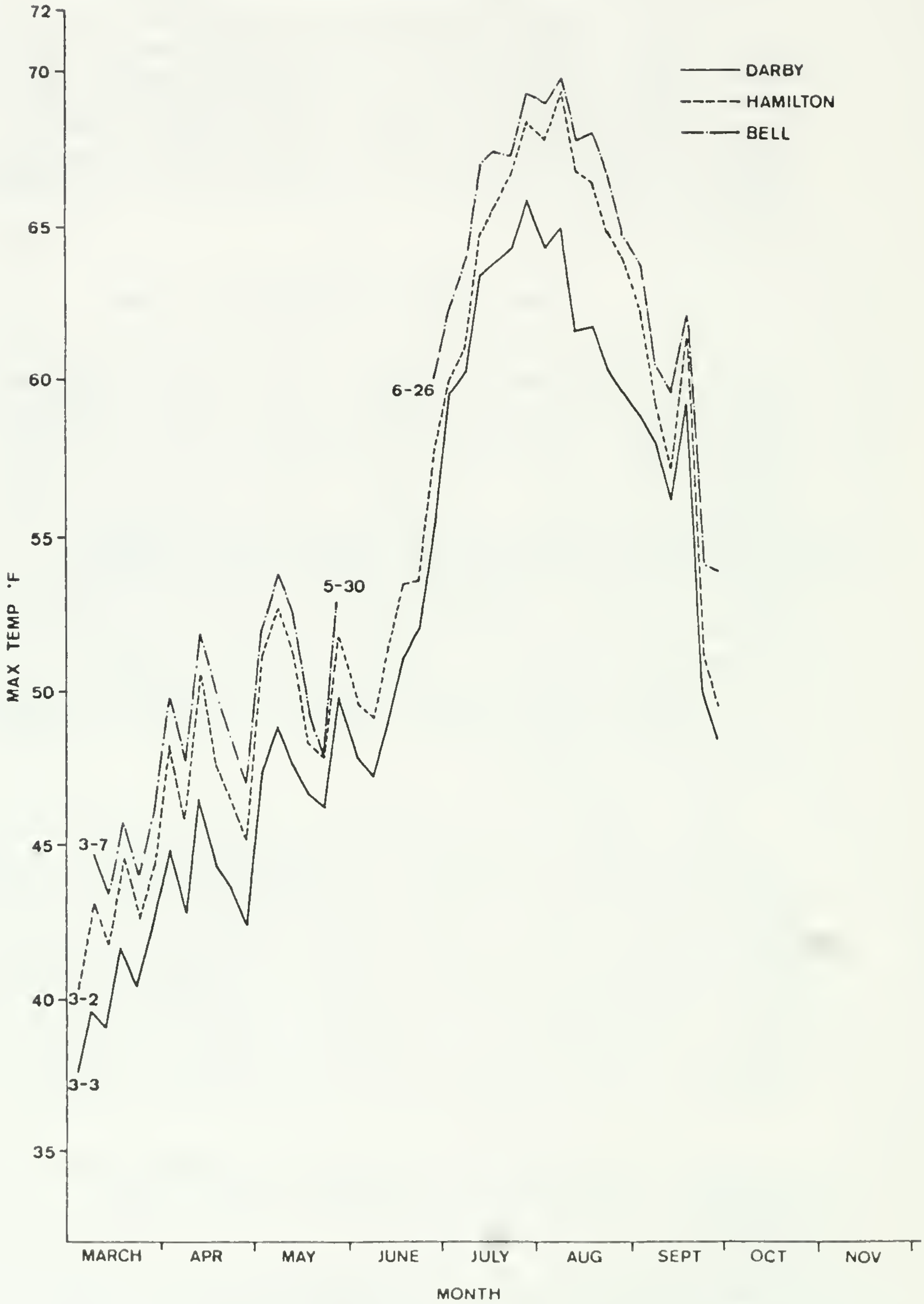

Figure 14. Five day averages of maximum temperatures recorded at the Darby, Hamilton and Bell stations on the Bitterroot River during 1984.

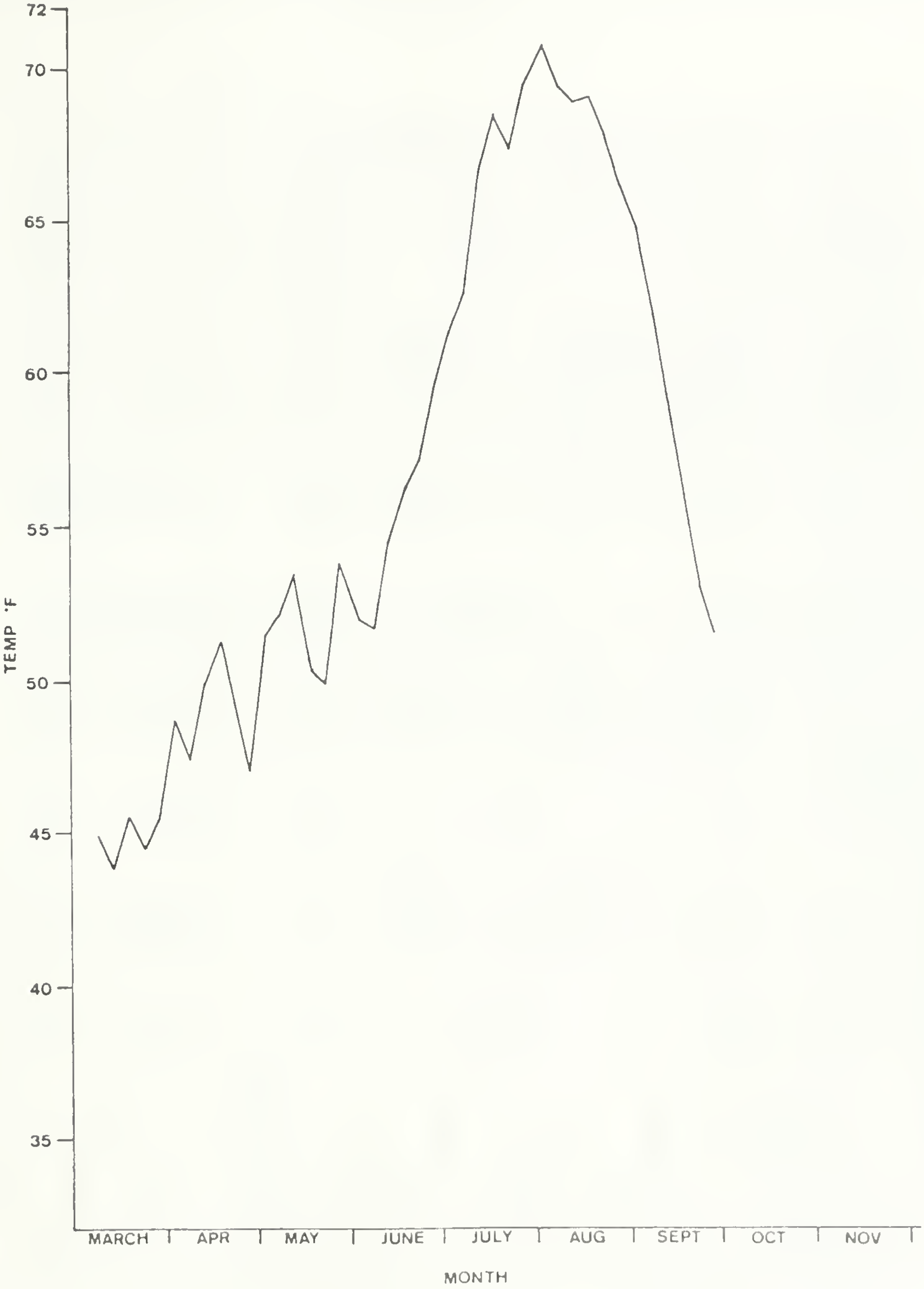

Figure 15. Five day averages of maximum temperatures recorded at the McClay station on the Bitterroot River during 1984.

Table 3. Mean and range (in parentheses) of values for chemical parameters measured at stations on the Bitterroot River and irrigation returns during 1983 and 1984.

	Bitterroot River[1]						Irrigation Returns[1]			
	Station 1		Station 2		Station 3		Station 4		Station 5	
Parameter	1983	1984	1983	1984	1983	1984	1983	1984	1983	1984
Lab Determinations										
pH	7.82 (7.7-8.0)	7.55 (7.5-7.6)	7.95 (7.9-8.0)	7.79 (7.7-7.9)	8.10 (8.1)	7.96 (7.8-8.2)	- -	8.48 (8.0-9.3)	8.35 (8.3-8.4)	8.10 (7.9-8.4)
HCO_3^- (mg/1)	- -	40.7 (26.9-50.8)	- -	56.1 (26.9-71.0)	- -	72.9 (37.8-93.6)	- -	118.2 (78.5-147.4)	- -	160.5 (148.6-174.8)
Total nitrogen (mg/1)	- -	0.49 (0.37-0.68)	- -	0.25 (0.12-0.37)	- -	0.26 (0.16-0.42)	- -	0.60 (0.14-1.83)	- -	0.75 (0.38-1.55)
NO_3-N (mg/1)	- -	0.012 (0.003-0.026)	- -	0.012 (0.003-0.020)	- -	0.029 (0.012-0.051)	- -	0.060 (<0.001-0.173)	- -	0.25 (0.114-0.475)
Total ammonia (mg/1)	<0.015 (<0.01-0.02)	<0.01 (<0.01)	<0.01 (<0.01)	<0.01 (<0.01-0.01)	<0.015 (<0.01-0.02)	<0.020 (<0.01-0.05)	- - -	<0.01 (<0.01-0.02)	0.015 (0.01-0.02)	0.06 (<0.01-0.16)
Total phosphorus (mg/1)	- -	0.015 (0.010-0.024)	- -	0.017 (0.009-0.033)	- -	0.023 (0.014-0.044)	- -	0.041 (0.011-0.112)	- -	0.049 (0.030-0.095)
Conductivity (umhos/cm)	76.5 (75-78)	74.1 (67-93)	95.5 (91-100)	98.1 (37-124)	114.0 (110-118)	123.9 (54-158)	- -	199.9 (133-282)	271 (264-278)	270.8 (242-295)
Field Determinations										
pH	7.62 (7.4-7.8)	6.56 (6.4-6.9)	8.05 (8.0-8.1)	6.70 (6.5-7.8)	8.42 (8.3-8.6)	6.74 (6.6-7.0)	- -	7.12 (6.8-8.4)	8.40 (8.2-8.8)	6.81 (6.6-7.8)
Dissolved oxygen (mg/1)	10.15 (9.30-11.35)	9.62 (8.25-11.20)	11.15 (10.80-11.50)	9.19 (7.55-11.60)	11.07 (10.50-11.50)	9.78 (8.60-11.70)	- - -	12.58 (9.90-14.20)	12.38 (11.95-12.80)	11.49 (10.10-12.60)
Total alkalinity (mg/1 as $CaCO_3$)	48 (44-50)	35 (20-50)	53 (50-55)	44 (24-53)	65 (57-77)	54 (30-75)	- -	94 (67-140)	128 (117-138)	106 (50-137)

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[1] Station 1 - Bitterroot River near Darby
Station 2 - Bitterroot River 4.8 km above bridge at Stevensville
Station 3 - Bitterroot River at bridge at Stevensville
Station 4 - Irrigation return 1.5 km above Victor crossing
Station 5 - Irrigation return 4.8 km above bridge at Stevensville

corded in the lower river were much less than the critical thermal maxima of 28C (82F) reported for trout by Lee and Rhine (1980) and are probably adequate for trout viability.

Water Quality Parameters

Water quality was monitored during 1983 and 1984 at three stations established on the Bitterroot River and at two stations established on irrigation returns (Figure 1). The values of selected chemical parameters measured at the five stations are presented in Appendix Tables 7-15. The mean values and ranges of these chemical parameters are given in Table 3. Mean values of pH, bicarbonate, total phosphorus, conductivity, and total alkalinity increased in a downstream direction at successive stations on the Bitterroot River. These increases were probably due to inputs of chemical constituents from tributary inflow and from irrigation returns. Mean values of all measured parameters, excepting pH and total ammonia, were greater in the irrigation returns than in the Bitterroot River. A comparison of ionic concentrations among the five stations, as measured by specific conductance, is shown in Figure 16.

Based on the chemical parameters that were monitored, water in the Bitterroot River can be considered favorable in quality. Total nitrogen and phosphorus levels measured in the river were less than problem criteria for running waters given by the Environmental Protection Agency (Mills et al. 1982). The Environmental Protection Agency (EPA) criteria are presented in Table 4.

Table 4. EPA criteria for total phosphorus and nitrogen in running waters.

Total Phosphorus (mg/l)	Total Nitrogen (mg/l)	Significance
0.013	0.092	Problem threshold
0.13	0.92	Problem likely
1.3	9.2	Severe problem

Although less than the problem criteria given by EPA, nutrient levels in the irrigation returns were substantially greater than levels in the river. The source of these nutrients was apparently from the application of fertilizers on surrounding farmlands and from livestock wastes. The presence of dense growths of aquatic vegetation within the irrigation returns was probably a result of these higher nutrient levels.

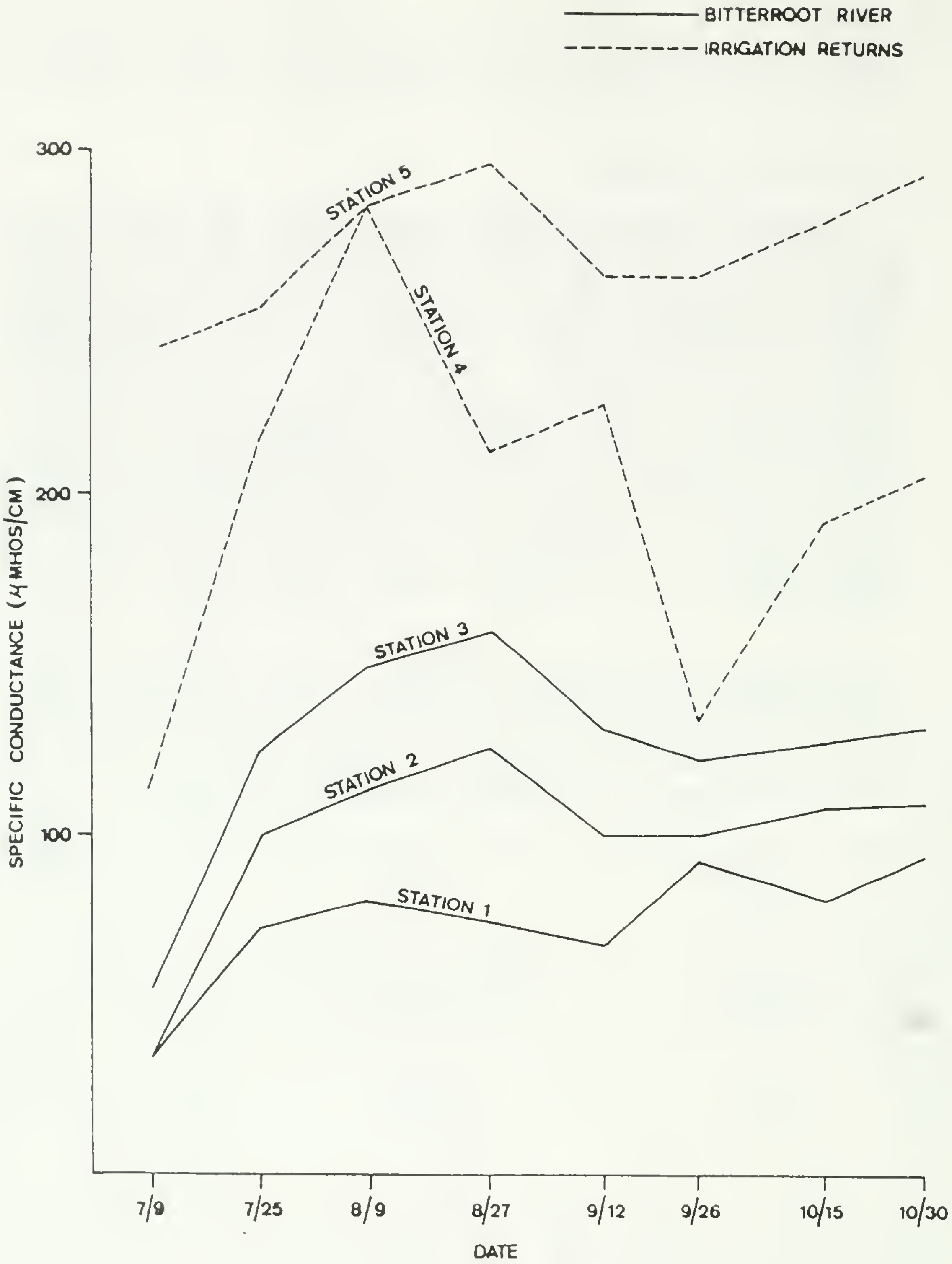

Figure 16. Measurements of conductivity (u mhos/cm) in the Bitterroot River and irrigation returns during 1984.

The un-ionized form of ammonia is toxic to freshwater aquatic life. The presence of this un-ionized form is dependent upon total ammonia concentration, pH, temperature and ionic strength. Total ammonia concentrations monitored in the river and irrigation returns were well below concentrations needed to reach toxic levels of the un-ionized form within the ranges of pH and temperature measured at the five stations. The EPA criterion for ammonia in un-ionized form is 0.02 mg/l (Environmental Protection Agency 1976). Ammonia concentrations monitored at the five stations were relatively low despite the common use of anhydrous ammonia as fertilizer on surrounding farmlands.

The values for pH, bicarbonate, nitrate, and alkalinity measured at the five stations were within the range of values expected to occur in relation to the geologic characteristics of the valley. The values for dissolved oxygen monitored at the five stations were commonly above saturation levels. These data indicate favorable water quality in the Bitterroot River. Water quality will continue to be monitored through November, 1984.

Physical Characteristics Of Study Sections

Selected physical characteristics measured in the Darby, Tucker East and Tucker West sections are presented in Table 5. Differences in widths and depths among the study sections were partially due to the presence of side channels and to the characteristic channel split of the Tucker section. The mean number of channels containing water was significantly greater in the Darby and Tucker East sections than the Tucker West section. Few side channels were present in the Tucker West section. Mean total widths (side channels included) were significantly different among the three study sections. Total width was greatest in the Darby section, intermediate in the Tucker East section, and least in the Tucker West section. Width of the dominant channel was significantly greater in the Darby section than in the two Tucker sections. Mean depths and thalweg depths in the Darby and Tucker West sections were not significantly different, but were significantly greater than in the Tucker East section. These data indicate the dominant channel of the Darby section was relatively wide and deep in comparison to the narrow, shallow channel of the Tucker East section and the narrow, deep channel of the Tucker West section.

Pool numbers as measured by pool-riffle periodicity were not significantly different among study sections. In contrast, the pool-riffle ratio was less in the Darby section than in the Tucker East and Tucker West sections. Average pool length was similar among study sections. Mean riffle length, however, was

Table 5. Selected physical characteristics of study sections in the Bitterroot River measured during August, 1984. Standard deviations in parentheses.

Parameter	Section Darby	Tucker East	Tucker West
Mean number of channels	1.55 (0.68)	1.68 (0.66)	1.05 (0.22)
Mean total width (m)[1]	45.4 (10.3)	37.9 (13.1)	27.7 (8.2)
Mean dominant channel width (m)	42.2 (9.4)	25.9 (8.1)	27.2 (8.1)
Mean depth (cm)	54 (37)	44 (33)	52 (36)
Mean thalweg depth (cm)	96 (34)	75 (31)	93 (34)
Pool-riffle periodicity	8.11 (3.62)	7.29 (2.56)	10.98 (4.78)
Mean pool length (m)	187.9 (91.7)	143.6 (70.5)	228.9 (111.2)
Mean riffle length (m)	155.5 (135.6)	45.1 (19.0)	69.5 (42.2)
Pool riffle ratio	1.21	3.19	3.29
Gradient %	3.21	2.44	2.44
Discharge (m^3/sec)[2]	12.0-16.3	6.0-6.3	5.2-6.0
Section length (km)	9.36	8.88	8.95
Surface area (km^2)	0.425	0.337	0.248

[1] sum of main channel and side channel widths

[2] discharge when characteristics were measured

significantly greater in the Darby section than the two Tucker sections. These data indicate the Darby section contained a greater quantity of riffle habitat than the Tucker East and Tucker West sections.

The surface areas of potential overhanging and instream cover in the three study sections are presented in Table 6. The total amount of potential cover present was less in the Darby and Tucker East sections than the Tucker West section. The Tucker West section contained approximately 200% more cover than did the other two sections. Shoreline debris was the dominant cover type in the Darby section, comprising 36.7% of the total amount of cover present. Instream debris was the dominant cover type in the Tucker East and Tucker West sections. Instream debris comprised 44.1 and 49.1% of the total amount of cover present in the Tucker East and Tucker West sections, respectively. A majority of the debris in all three sections was composed of snags from fallen cottonwood and conifer trees.

Several studies have demonstrated the importance of pool area and cover to trout populations (Boussu 1954, Lewis 1969, Enk 1977). Based on pool and cover characteristics measured in the Bitterroot River, the amount of potential habitat for trout appears to be greater in the Darby and Tucker West sections than in the Tucker East section. However, pool and cover features represent only a general measure of habitat quality. Seasonal fluctuations in flow, especially the historical problem of dewatering in the Tucker section, is probably a major factor in determining carrying capacity for trout in the Bitterroot River.

Parameters Of Salmonid Populations

Population estimates

The numbers and sizes of each species of trout captured in the study sections during the Fall, 1983 are presented in Appendix Table 16. Rainbow trout was the dominant species in the Darby section, comprising 55% of the total numbers of trout collected. In contrast, brown trout was the dominant species in the Tucker section, comprising 63% of the total numbers of trout collected. Rainbow trout and brown trout captured in the Darby section were smaller in mean total length and weight than those collected in the Tucker section.

Estimates of the numbers and biomass of I+ and older rainbow trout and brown trout obtained from the Darby (control) and Tucker (dewatered) sections during the Fall, 1983 are presented in Table 7. Densities of rainbow trout per kilometer (km) were significantly greater in the Darby section than the Tucker section. Numbers of rainbow trout estimated in the Darby section were about 335% greater than the numbers estimated in the Tucker section. Numbers of brown trout estimated per km were not significantly

Table 6. Area (m^2/400m) of potential cover in the study sections of the Bitterroot River measured during August, 1984.

Cover Type	Section Darby	 Tucker East	 Tucker West
Shoreline overhang			
Brush[1]	14.94	3.81	51.82
(% of total cover)	(18.5)	(4.8)	(19.8)
Debris[2]	29.57	15.24	19.20
(% of total cover)	(36.7)	(19.3)	(7.3)
Undercut[3]	7.32	8.23	24.38
(% of total cover)	(9.1)	(10.5)	(9.3)
Rock shelf[4]	22.10	16.76	38.10
(% of total cover)	(27.4)	(21.3)	(14.5)
Instream			
Debris[2]	6.71	34.75	128.93
(% of total cover)	(8.3)	(44.1)	(49.1)
Total Cover	80.62	78.79	262.43

[1] Overhanging rooted woody vegetation

[2] Snags, driftwood, and logs

[3] Undercut streambanks

[4] Shelves of rock within or overhanging the water

Table 7. Estimates of numbers (N), biomass and age structures of rainbow trout and brown trout in the study sections of the Bitterroot River obtained during the Fall, 1983. 80% confidence intervals in parentheses.

			Per Kilometer		Per Mile	
Section	Species	Age Group	N	Biomass (kg)	N	Biomass (kg)
Darby	Rainbow trout	I+	173	10.11	279	16.27
		II+	148	27.01	239	43.47
		III+	118	42.71	190	68.74
		IV+ and older	53	29.86	85	48.06
		Total	492	109.69	793	176.54
			(363-621)	(88.22-131.16)	(585-1001)	(141.99-211.09)
	Brown Trout	I+	53	3.91	86	6.29
		II+	42	9.69	67	15.59
		III+	23	12.23	38	19.68
		IV+ and older	21	18.86	34	30.35
		Total	139	44.69	225	71.91
			(113-165)	(37.37-52.01)	(184-266)	(60.13-83.69)
Tucker (East Channel)	Rainbow trout	I+	No Estimate		No Estimate	
		II+	15	2.47	24	3.98
		III+	24	7.69	38	12.38
		IV+ and older	26	18.67	42	30.05
		Total	65	28.83	104	46.41
			(53-77)	(24.33-33.33)	(85-123)	(39.18-53.64)
	Brown Trout	I+	12	1.74	19	2.79
		II+	12	2.87	20	4.63
		III+	14	7.27	22	11.70
		IV+ and older	27	26.42	43	42.51
		Total	65	38.30	104	61.63
			(58-72)	(33.45-43.15)	(93-115)	(53.82-69.44)
Tucker (West Channel)	Rainbow Trout	I+	5	0.29	7	0.47
		II+	15	2.01	25	3.24
		III+	13	4.17	21	6.71
		IV+ and older	16	10.83	25	17.42
		Total	49	17.30	78	27.84
			(38-60)	(13.35-21.25)	(60-96)	(21.48-34.20)
Tucker (West Channel)	Brown Trout	I+	12	1.13	20	1.81
		II+	20	3.54	32	5.70
		III+	16	6.85	25	11.02
		IV+ and older	26	26.87	42	43.24
		Total	74	38.39	119	61.77
			(63-85)	(33.73-43.05)	(101-137)	(54.27-69.27)
Tucker (Combined)	Rainbow Trout	Total	114	46.13	182	74.25
			(98-130)	(40.14-52.12)	(156-208)	(64.55-83.78)
	Brown Trout	Total	139	76.69	223	123.40
			(126-152)	(69.96-83.42)	(202-244)	(112.63-134.31)

different between the Darby and Tucker sections. However, the biomass of brown trout was significantly less (42%) in the Darby section than the Tucker section. Trout densities estimated per km, with the exception of rainbow trout biomass, were not significantly different between east and west channels of the Tucker section. The estimated biomass of rainbow trout was significantly greater in the east channel than in the west channel.

Age and size structures of the population estimates obtained in the Darby and Tucker sections during the Fall, 1983 are compared in Figure 17. Age I+ fish comprised the greatest proportion of numbers among age groups in the Darby section. In contrast, age IV+ and older fish dominated numbers among age groups in the Tucker section. Differences in size structures between study sections were reflective of age structure differences.

During the fall of 1982, rainbow trout densities in the Darby section were estimated by the Montana Department of Fish, Wildlife and Parks (Table 8). Estimated numbers of rainbow trout were not significantly different between 1982 and 1983. However, biomass estimates of rainbow trout were significantly less in 1982 than in 1983.

The numbers and sizes of each species of salmonid captured in the study sections during the Spring, 1984 are presented in Appendix Table 17. Mountain whitefish was the dominant salmonid species collected in both study sections. Among trout species, rainbow trout comprised a majority of the total numbers collected in the Darby section. Brown trout comprised a majority of the total numbers of trout collected in the Tucker section. These catch statistics were similar to the collections obtained during the Fall, 1983.

Estimates of the numbers and biomass of II+ and older rainbow trout and brown trout obtained from the two study sections during the Spring, 1984 are presented in Table 9. Estimates for densities of yearling trout were not obtained because these fish were too small to capture by electrofishing. Additionally, estimates for densities of age II+ fish were considered to be partial because only a portion of these fish were large enough to be captured by electrofishing.

Densities of rainbow trout estimated per km during the spring were not significantly different between the Darby and Tucker sections. In contrast, densities of brown trout per km were significantly less in the Darby section than in the Tucker section. Trout densities estimated per km were similar between the east and west channels of the Tucker section.

The estimates for total densities of trout obtained during the Spring, 1984 were not comparable to those obtained during the Fall, 1983. However, estimates of age III+ and older trout were comparable between years. In the Darby section, estimated numbers

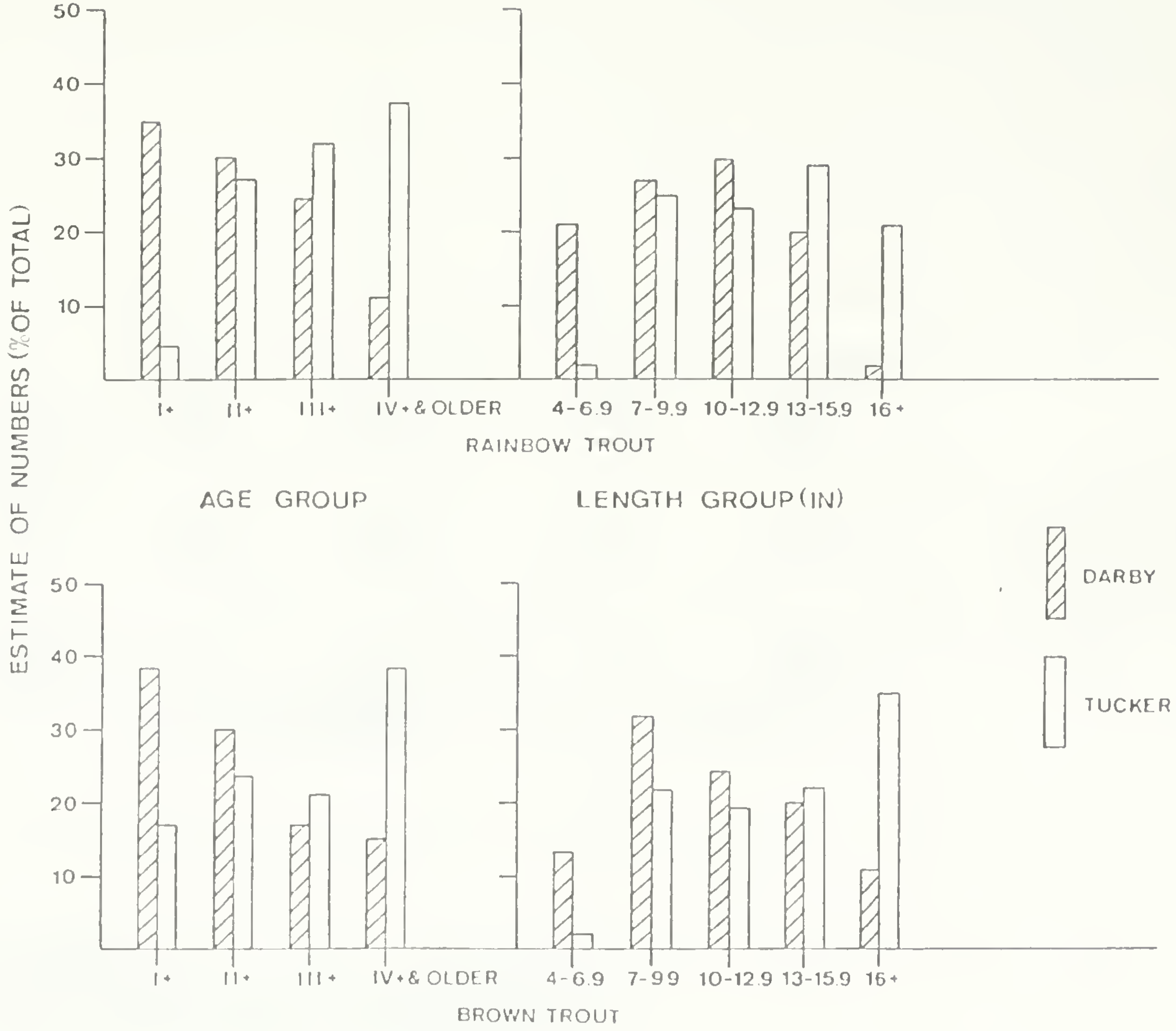

Figure 17. Age and size structures of rainbow trout and brown trout populations estimated in the study sections of the Bitterroot River during the fall of 1983.

Table 8. Estimates of numbers (N), biomass and age structure of rainbow trout in the Darby section of the Bitterrooot River obtained during the Fall, 1982. 80% confidence intervals in parentheses.

Section	Species	Age Group	Per Kilometer		Per Mile	
			N	Biomass (kg)	N	Biomass (kg)
Darby	Rainbow Trout	I+	121	6.49	194	10.45
		II+	111	19.78	178	31.83
		III+	64	24.47	103	39.39
		IV+ & older	22	13.07	35	21.04
		Total	318	63.81	510	102.71
			(231-405)	(47.48-80.14)	(370-650)	(76.43-128.99)

Table 9. Estimates of numbers (N), biomass, and age structures of rainbow trout and brown trout in the study sections of the Bitterroot River obtained during the Spring, 1984. 80% confidence intervals in parentheses.

Section	Species	Age Group	Per Kilometer N	Per Kilometer Biomass (kg)	Per Mile N	Per Mile Biomass (kg)
Darby	Rainbow trout	I+	no estimate		no estimate	
		II+[a]	11	0.85	18	1.36
		III+	58	13.96	94	22.47
		IV+ & older	93	43.46	149	69.94
		Total	162	58.27	261	93.77
			(136-188)	(49.64-66.90)	(219-303)	(79.89-107.65)
	Brown Trout	I+	no estimate		no estimate	
		II+[a]	13	1.15	22	1.84
		III+	24	7.02	39	11.30
		IV+ & older	19	12.37	31	19.91
		Total	56	20.54	92	33.05
			(41-71)	(17.24-23.84)	(67-117)	(27.75-38.35)
Tucker (E. Channel)	Rainbow Trout	I+	no estimate		no estimate	
		II+[a]	4	0.61	6	0.98
		III+	24	7.94	38	12.78
		IV+ & older	52	33.67	84	54.19
		Total	80	42.22	128	67.95
			(56-104)	(29.14-55.30)	(89-167)	(46.91-88.99)
	Brown Trout	I+	no estimate		no estimate	
		II+[a]	10	2.25	16	3.63
		III+	18	6.91	30	11.12
		IV+ & older	27	23.07	44	37.13
		Total	55	32.23	90	51.88
			(45-65)	(27.89-36.57)	(74-106)	(44.89-58.87)
Tucker (W. Channel)	Rainbow Trout	I+	no estimate		no estimate	
		II+[a]	8	1.31	13	2.10
		III+	23	8.63	37	13.89
		IV+ & older	44	29.44	71	47.37
		Total	75	39.38	121	63.36
			(54-96)	(30.46-48.30)	(87-155)	(49.01-77.71)
	Brown Trout	I+	no estimate		no estimate	
		II+[a]	13	2.00	21	3.22
		III+	25	8.40	40	13.52
		IV+ & older	24	17.75	39	28.57
		Total	62	28.15	100	45.31
			(50-74)	(24.4-31.9)	(81-119)	(39.28-51.34)
Tucker	Rainbow Trout	Total	155	81.60	249	131.31
			(123-187)	(65.77-97.43)	(197-301)	(105.87-156.75)
	Brown Trout	Total	117	60.38	190	97.19
			(111-133)	(54.64-66.12)	(165-215)	(87.96-106.42)

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[a] partial estimate

of age III+ and older rainbow trout and brown trout were similar between the Fall, 1983 and the Spring, 1984. In the Tucker section, estimated numbers of age III+ and older rainbow trout substantially increased between the fall and the spring. This increase may have been due to spawning movements made by rainbow trout during the spring. Numbers of age III+ and older brown trout estimated in the Tucker section were similar between the fall and the spring.

Estimates of the numbers and biomass of mountain whitefish greater than 254mm (10 in.) in total length obtained from the two study sections during the Spring, 1984 are presented in Table 10. Densities of mountain whitefish per km were not signficantly different between sections. The potential for substantial differences in mountain whitefish densities between sections, however, were undetectable due to the broad confidence intervals computed for these estimates.

The numbers and sizes of each species of trout captured in the study sections during the Fall, 1984 are presented in Appendix Table 18. Again, these catch statistics were similar to statistics from the previous collections. Final computations of population estimates for the Fall, 1984 will be made when age analyses are completed and will be presented in the final report.

The estimate data obtained from the Bitterroot River indicate historical dewatering of the river has reduced the rainbow trout fishery within the Tucker section. Brown trout apparently are more tolerant to dewatering than rainbow trout. However, additional factors in the Darby and Tucker sections, including undetected differences in habitat characteristics and differential fishing pressure, may be influencing the carrying capacities for trout populations in these study reaches. Additional population estimates should be obtained in these sections during the next two to four years to fully evaluate the effect supplemental water will have on trout populations within the dewatered reach of the Bitterroot River.

Condition factors

Mean condition factors computed for rainbow trout, brown trout and mountain whitefish greater than 127 mm (5 in.) in total length collected in the Darby and Tucker sections during the fall of 1982, the fall of 1983 and the spring of 1984 are shown in Table 11. The mean condition factors for each species of salmonid did not appear to vary between study sections or among years. Statistical analysis of condition factors will be presented in the final report.

Table 10. Estimates of numbers (N), biomass, and age structures of mountain whitefish in the study sections of the Bitterroot River obtained during the Spring, 1984. 80% confidence intervals in parentheses.

Section	Species	Age Group	Per Kilometer N	Per Kilometer Biomass (kg)	Per Mile N	Per Mile Biomass (kg)
Darby	Mountain Whitefish	III+[a]	90	14.3	145	23.1
		IV+	1,335	234.0	2,148	376.6
		V+	4,958	1,043.7	7,978	1,679.5
		VI+ and older	1,293	350.7	2,081	564.3
		Total	7,676 (4,345-11,007)	1,642.7 (968.1-2,317.3)	12,352 (6,991-17,713)	2,643.5 (1,558.0-3,729.0)
Tucker (East Channel)	Mountain Whitefish	III+[a]	237	42.2	382	67.9
		IV+	1,018	204.9	1,640	329.8
		V+	1,100	256.6	1,771	413.1
		VI+ and older	270	92.5	434	149.0
		Total	2,625 (1,734-3,516)	596.2 (410.0-782.4)	4,227 (2,792-5,662)	959.8 (660.0-1,259.6)
Tucker (West Channel)	Mountain Whitefish	III+[a]	313	54.6	504	87.9
		IV+	372	74.8	599	120.4
		V+	606	147.3	976	237.2
		VI+ and older	337	126.6	543	203.9
		Total	1,628 (1,247-2,009)	403.3 (307.0-499.6)	2,622 (2,008-3,236)	649.4 (494.3-804.5)
Tucker (Combined)	Mountain Whitefish	Total	4,253 (3,284-5,222)	999.5 (789.9-1,209.1)	6,849 (5,288-8,410)	1,609.2 (1,271.7-1,946.7)

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[a] partial estimate

Table 11. Mean condition factors (k) for salmonids greater than 127mm (5in) in total length from study sections of the Bitterroot River during 1982, 1983, and 1984. Standard deviations in parentheses.

Section	Species	K Fall 1982	 Fall 1983	 Spring 1984
Darby	Rainbow Trout	1.00 (0.11)	1.06 (0.14)	1.01 (0.09)
	Brown Trout		1.09 (0.14)	0.99 (0.10)
	M. Whitefish			0.93 (0.08)
Tucker (E. Channel)	Rainbow Trout		1.04 (0.09)	1.04 (0.11)
	Brown Trout		1.02 (0.09)	1.00 (0.09)
	M. Whitefish			0.92 (0.08)
Tucker (W. Channel)	Rainbow Trout		1.04 (0.12)	1.02 (0.10)
	Brown Trout		1.01 (0.10)	0.98 (0.09)
	M. Whitefish			0.93 (0.08)

Growth Rates

The mean total length at time of capture and the back-calculated lengths at age for rainbow trout and brown trout collected during the Fall, 1983 are given in Tables 12 and 13, respectively. The regression formula used for rainbow trout was:

$$\text{Predicted length} = 7.12494 \times (\text{scale measurement})^{0.88338}$$

$$r^2 = 0.93$$

For brown trout:

$$\text{Predicted length} = 5.42503 \times (\text{scale measurement})^{0.95048}$$

$$r^2 = 0.95$$

The growth increments of back-calculated length for rainbow trout in the Darby, Tucker (east channel) and Tucker (west channel) sections averaged 75.6 mm (2.98 in.), 68.3 mm (2.69 in.) and 65.5 mm (2.58 in.), respectively. For brown trout, the increments of back-calculated length in the Darby, Tucker (east channel) and Tucker (west channel) sections averaged 79.5 mm (3.13 in.), 83.3 mm (3.28 in.) and 81.3 mm (3.20 in.), respectively. Growth curves of rainbow trout and brown trout computed for the study sections are compared graphically in Figure 18. Growth rates for both species appeared similar among sections. Analyses of age and growth for trout collected during the Spring and Fall, 1984 have not been completed. These data will be presented in the final report. Length frequency distributions of rainbow trout, brown trout and mountain whitefish collected in the Darby and Tucker sections during the fall of 1983, the spring of 1984 and the fall of 1984 are shown in Appendix Figures 10-16.

Trout spawning

Sections of the Bitterroot River located between Hamilton and Stevensville were electrofished during the Fall, 1983 to monitor brown trout spawning. The sexual maturity of brown trout collected during the Fall, 1983 is shown graphically in Figure 19. The progressive decline in the percentage of fish classified as ripe or gravid and the progressive increase in the percentage of fish classified as spent indicated the peak of spawning activity occurred during late October or early November. Spawners (ripe, gravid or spent) averaged 439 mm (17.3 in.) in total length and 849 gm (1.87 lbs) in weight.

During the monitoring period, a total of 58 brown trout redds was observed in the river. All redd sites, with the exception of one, were located in side channels. Preference for side channels by spawning brown trout was apparently related to appropriate

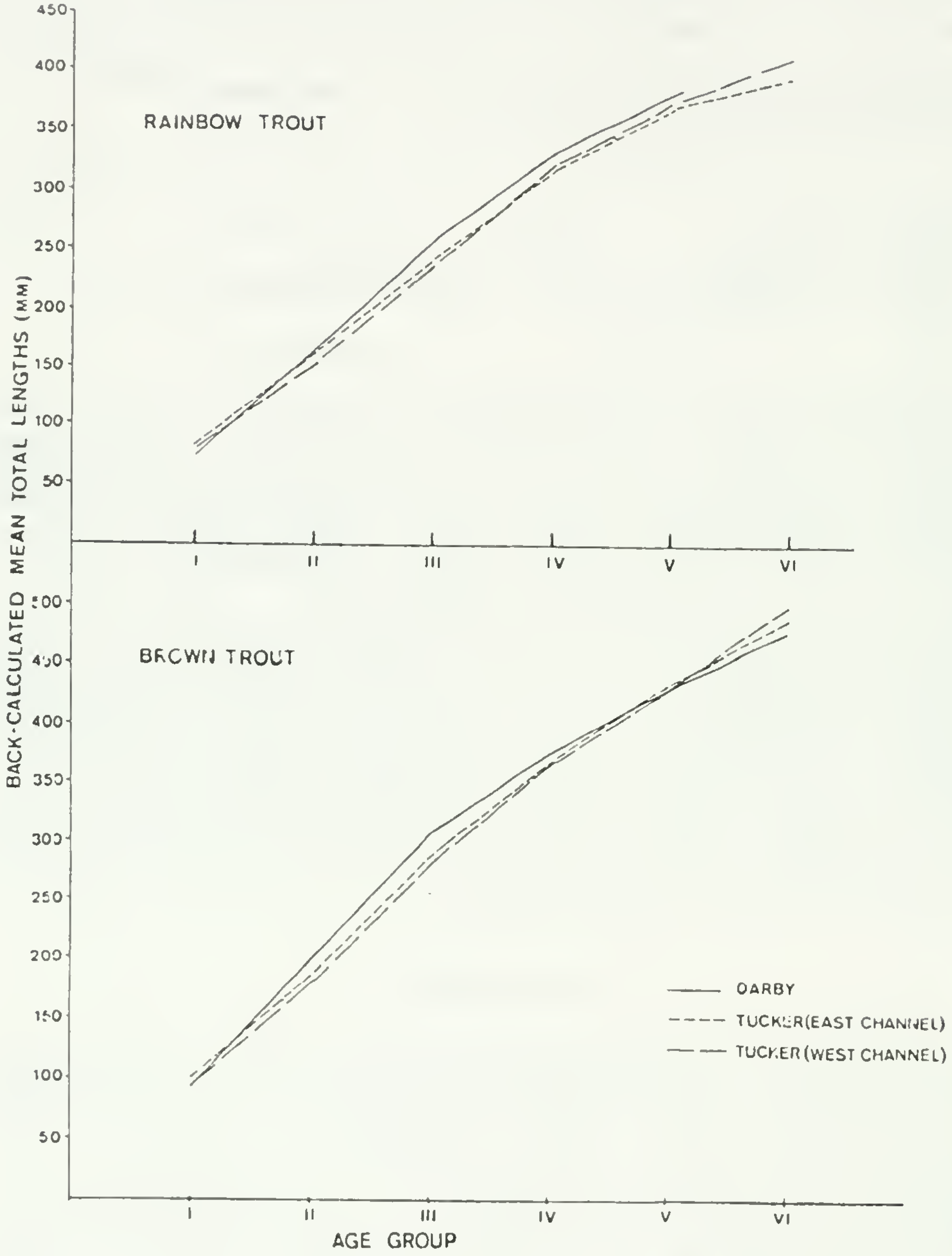

Figure 18. Growth curves of rainbow trout and brown trout collected in the study sections of the Bitterroot River during the fall of 1983.

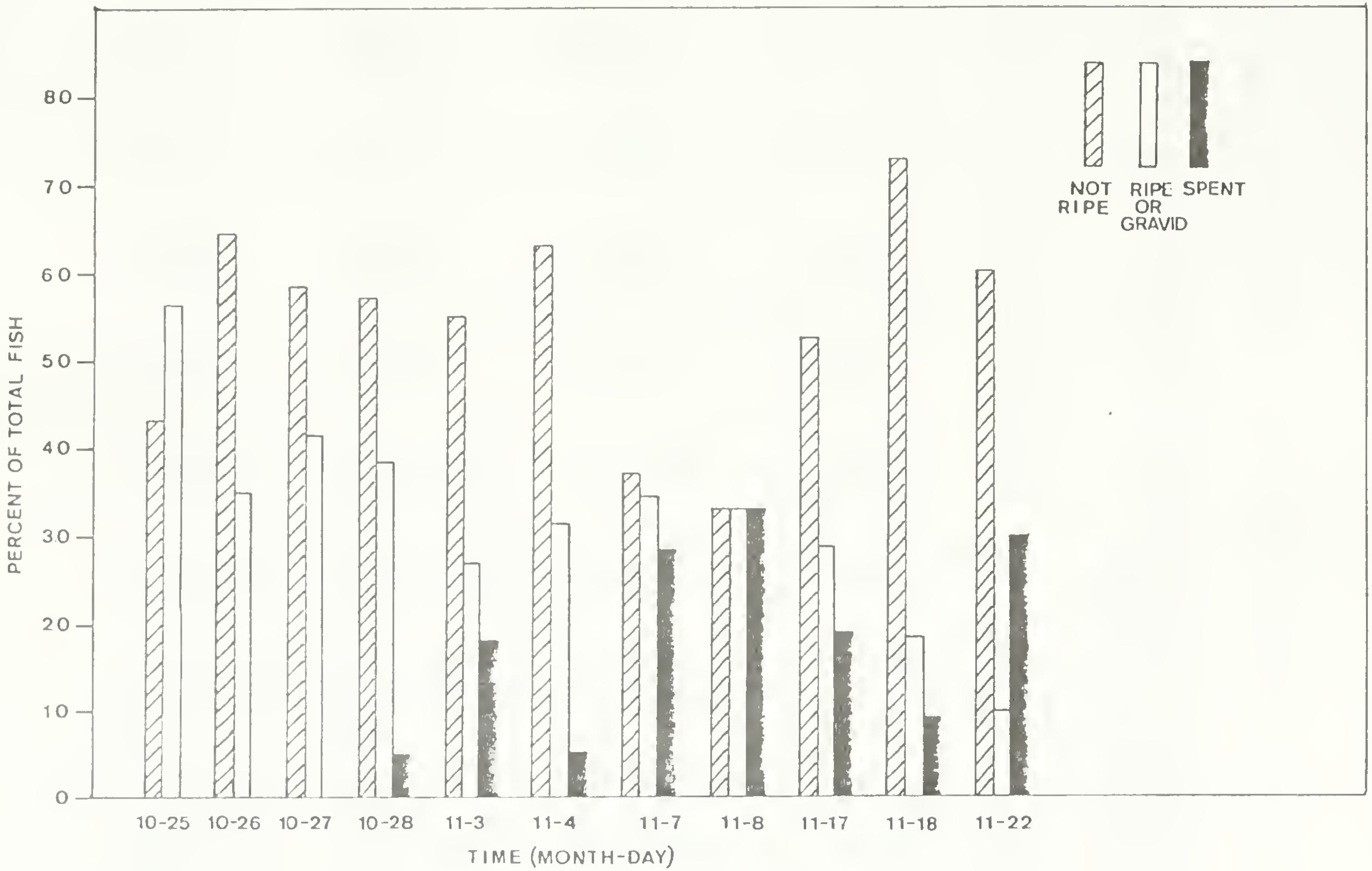

Figure 19. Sexual maturity of adult brown trout collected in the Bitterroot River during the fall of 1983.

Table 12. Mean total length (TL) at time of capture and back-calculated mean total length at age for rainbow trout in study sections of the Bitterroot River during the fall of 1983. Standard deviations in parentheses.

Section	Age Group	N	Mean TL at Capture (mm)	Calculated Length (mm) at Age					
				I	II	III	IV	V	VI
Darby	0+	8	72						
	I+	92	172	74					
	II+	89	257	74	159				
	III+	81	325	78	163	259			
	IV+	42	374	77	161	260	329		
	V+	10	406	77	159	255	325	378	
Mean back-calculated length (mm)				76(±13)	161(±31)	259(±32)	328(±27)	378(±29)	
Mean increment of back-calculated length (mm)				76	85	98	69	50	
Tucker (E. Channel)	0+	9	83						
	I+	10	100	75					
	II+	33	241	80	168				
	III+	54	316	79	167	241			
	IV+	30	395	89	164	252	330		
	V+	31	429	85	152	243	309	373	
	VI+	6	435	80	135	210	290	343	393
Mean back-calculated length (mm)				82(±14)	162(±32)	242(±35)	317(±43)	368(±34)	393(±41)
Mean increment of back-calculated length (mm)				82	80	80	75	51	25
Tucker (W. Channel)	0+	3	89						
	I+	12	157	82					
	II+	45	223	76	147				
	III+	38	325	83	169	243			
	IV+	33	390	81	150	245	328		
	V+	18	427	90	145	225	305	373	
	VI+	2	434	69	143	188	276	357	410
Mean back-calculated length (mm)				81(±15)	154(±33)	239(±34)	318(±35)	371(±24)	410(±44)
Mean increment of back-calculated length (mm)				81	73	85	79	53	39
Pooled Total	0+	20	80						
	I+	114	164	75					
	II+	167	245	76	158				
	III+	173	322	79	166	250			
	IV+	105	385	82	158	253	329		
	V+	59	424	85	151	240	310	374	
	VI+	8	435	77	137	205	287	347	397
Mean back-calculated length (mm)				78(±14)	159(±32)	248(±35)	320(±36)	370(±30)	397(±40)
Mean increment of back-calculated length (mm)				78	81	89	72	50	27

Table 13. Mean total length (TL) at time of capture and back-calculated mean total length at age for brown trout in study sections of the Bitterroot River during the fall of 1983. Standard deviations in parentheses.

Section	Age Group	N	Mean TL at Capture(mm)	Calculated Length(mm) at Age					
				I	II	III	IV	V	VI
Darby	0+	21	89						
	I+	73	187	88					
	II+	71	275	88	185				
	III+	44	358	95	202	300			
	IV+	38	412	102	213	313	372		
	V+	9	465	100	204	324	387	430	
	VI+	1	500	96	141	257	389	431	477
Mean back-calculated length (mm)				92(±17)	197(±39)	307(±41)	375(±33)	430(±24)	477
Mean increment of back-calculated length (mm)				92	105	110	68	55	47
Tucker (E. Channel)	0+	30	110						
	I+	42	206	96					
	II+	39	282	94	176				
	III+	37	359	101	185	278			
	IV+	27	421	112	194	288	368		
	V+	16	468	104	192	304	369	431	
	VI+	5	531	119	213	313	373	440	488
Mean back-calculated length (mm)				101(±18)	186(±35)	288(±33)	369(±34)	433(±34)	488(±22)
Mean increment of back-calculated length (mm)				101	85	102	81	64	55
Tucker (W. Channel)	0+	20	111						
	I+	36	193	83					
	II+	56	261	87	167				
	III+	56	348	97	182	267			
	IV+	28	425	100	174	276	359		
	V+	23	477	97	193	289	374	431	
	VI+	6	542	116	221	307	392	444	500
Mean back-calculated length (mm)				93(±18)	179(±39)	276(±39)	368(±40)	433(±46)	500(±94)
Mean increment of back-calculated length (mm)				93	86	97	92	65	67
Pooled Total	0+	71	104						
	I+	151	194	89					
	II+	166	273	89	177				
	III+	137	354	97	189	281			
	IV+	93	420	104	196	295	367		
	V+	48	472	100	195	301	375	431	
	VI+	12	534	116	211	305	384	441	
Mean back-calculated length (mm)				95(±18)	187(±39)	289(±40)	371(±36)	433(±38)	493(±65)
Mean increment of back-calculated length (mm)				95	92	102	82	62	60

physical characteristics such as velocities, depths, and substrate which were found there. Selected physical characteristics measured at 40 redd sites are presented in Table 14.

Rainbow trout spawning was monitored during the Spring, 1984 by electrofishing sections of the Bitterroot River located between Darby and Stevensville. The sexual maturity of rainbow trout collected in the reach of river between Darby and Hamilton is shown graphically in Figure 20. The progressive decline in the percentage of fish classified as ripe or gravid and the progressive increase in the percentage of fish classified as spent indicated the peak of spawning activity occurred during late April. Similar results were obtained for the reach of river between Hamilton and Stevensville (Figure 21). Beginning April 16, river flow substantially increased as a result of rainfall and snowmelt. This freshet may have been the mechanism for triggering the observed spawning activity. Spawners (ripe, gravid or spent) collected in the Darby to Hamilton reach averaged 372 mm (14.6 in.) in total length and 531 gm (1.17 lbs) in weight. In the Hamilton to Stevensville reach, spawners averaged 413 mm (16.3 in.) in total length and 719 gm (1.58 lbs) in weight.

A total of 16 rainbow trout redds was observed in the river during the monitoring period. The search for redds was limited in scope and was hindered by high river flows. Rainbow trout redds were found in both side channel and main channel habitat. Selected physical characteristics measured at four redd sites are presented in Table 15.

Trout Rearing

The border of the river in the Darby and Tucker sections was extensively electrofished during August and September, 1984 to identify habitat types used as rearing areas by young of the year (YOY) rainbow trout and brown trout. Main channel and side channel borders were categorized into four habitat types. These habitat types were identified as riffle areas with a rock border, riffle areas with a root/brush border, pool areas with a rock border and pool areas with a root/brush border.

Numbers of juvenile trout collected per 10 meters of river border in the Darby and Tucker sections are presented in Table 16. Based on catch per unit effort, numbers of juvenile trout were substantially more abundant in the Darby section than the Tucker section. Juvenile rainbow trout were more abundant than juvenile brown trout in the Darby section. In contrast, juvenile rainbow trout were less abundant than juvenile brown trout in the Tucker section. These relationships are similar to comparisons made between the population estimates obtained from the two sections during 1983.

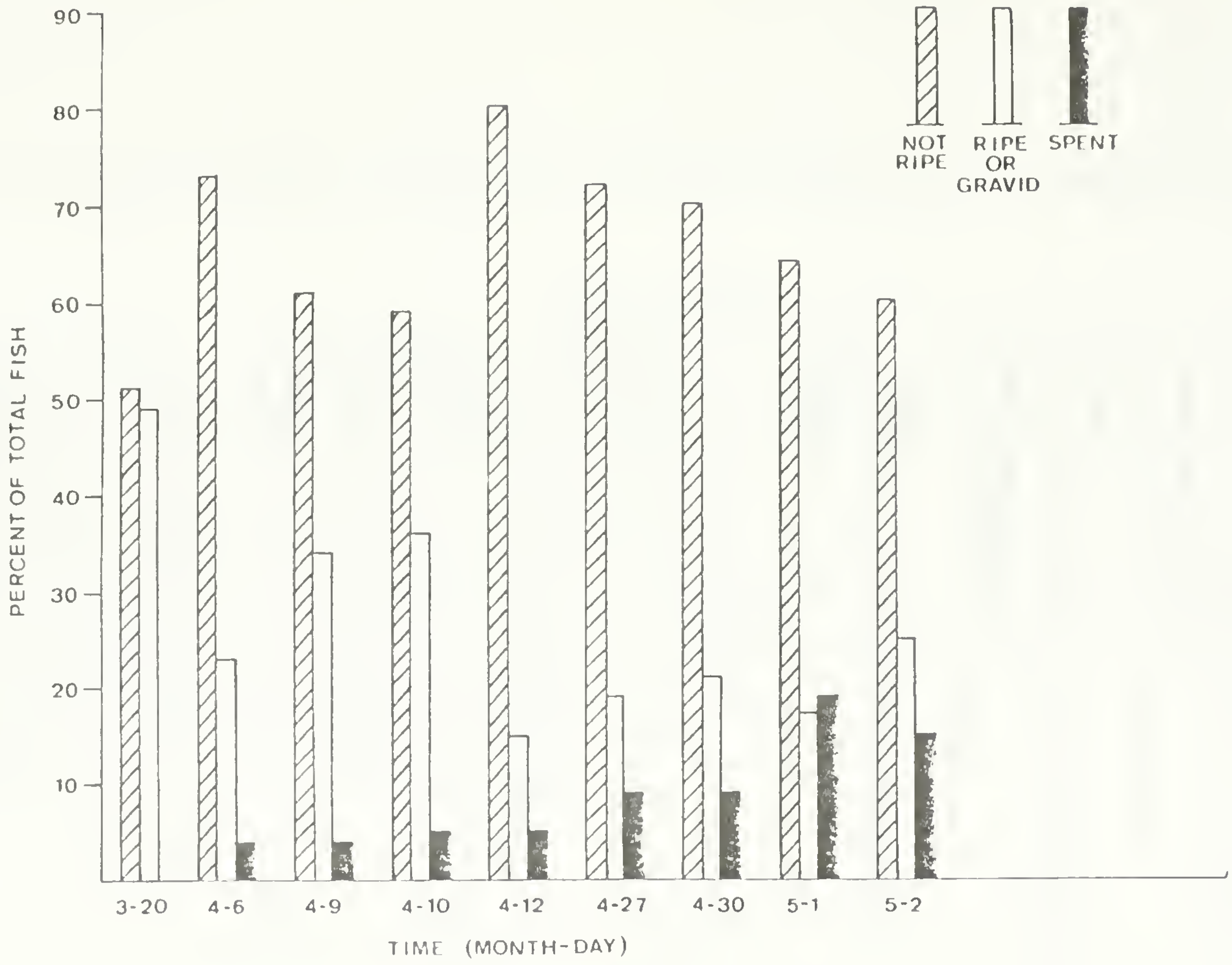

Figure 20. Sexual maturity of adult rainbow trout collected in the reach of the Bitterroot River between Darby and Hamilton during the Spring, 1984.

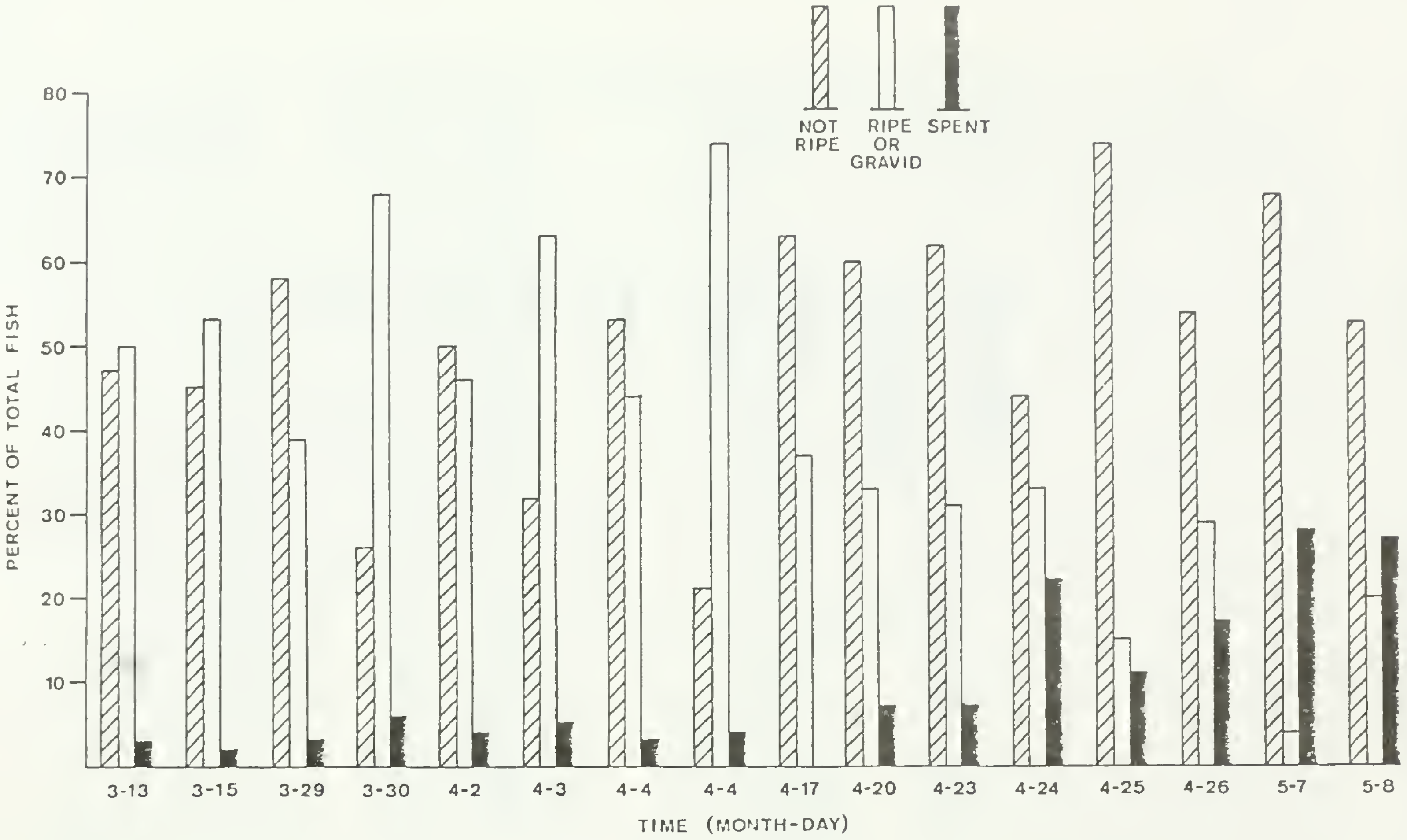

Figure 21. Sexual maturity of adult rainbow trout collected in the reach of the Bitterroot River between Hamilton and Stevensville during the Spring, 1984.

Table 14. Selected physical characteristics measured from brown trout redds in the Bitterroot River during the Fall, 1983.

	Area (m^2)	Mid-depth velocity (m/sec)	Bottom velocity (m/sec)	Depth (m)	Distance to shore (m)	Distance to cover (m)
N	39	40	40	40	40	39
Mean	2.69	0.73	0.45	0.49	2.58	7.47
Range	(0.18-6.04)	(0-1.09)	(0-0.78)	(0.24-0.82)	(0.30-9.14)	(0->30.5)

Table 15. Selected physical characteristics measured from rainbow trout redds in the Bitterroot River during the Spring, 1984.

	Area (m^2)	Mid-depth Velocity (m/sec)	Bottom Velocity (m/sec)	Dept (m)	Distance to share (m)	Distance to cover (m)
m	4	4	4	4	4	3
Mean	1.43	0.69	0.30	0.56	4.08	8.94
Range	(0.42-2.76)	(0.58-1.00)	(0.24-0.34)	(0.41-0.76)	(0.76-9.14)	(5.5-15.2)

Table 16. Numbers of young of year (YOY) rainbow trout and brown trout collected per 10 meters of river border in the study sections of the Bitterroot River during August and September, 1984.

	Darby			Tucker (East)			Tucker (West)		
		No. of YOY per 10m electrofished			No. of YOY per 10m electrofished			No. of YOY per 10m electrofished	
Habitat Type	Meters Electrofished	Rainbow Trout	Brown Trout	Meters Electrofished	Rainbow Trout	Brown Trout	Meters Electrofished	Rainbow Trout	Brown Trout
Side Channel									
Riffle rock border	96	3.33	3.12	261	0.38	0.88	76	3.15	3.4
Riffle root/brush border	128	0.78	2.03	180	0.28	2.17	38	1.57	2.89
Pool rock border	0	--	--	112	0.00	1.16	0	--	--
Pool root/brush border	62	0.96	0.48	34	0.00	0.30	80	0.50	0.38
Subtotal	286	1.68	2.06	587	0.26	1.29	194	1.75	2.06
Main Channel									
Riffle rock border	258	1.75	0.93	158	0.00	0.63	353	1.79	0.37
Riffle root/brush border	75	7.04	0.53	279	0.14	1.33	107	0.56	3.56
Pool rock border	73	3.69	1.23	125	0.24	1.85	332	0.09	0.39
Pool root/brush border	62	3.74	3.09	0	--	--	158	0.25	2.15
Subtotal	468	3.16	1.20	562	0.12	1.24	950	0.80	1.03
Grand Total	754	2.60	1.52	1149	0.19	1.27	1144	0.96	1.21

The utilization of habitat types by juvenile trout appeared to vary between species and among study sections. With the exception of rainbow trout in the Darby section, juvenile trout were more abundant in side channel habitat than main channel habitat. Additionally, juvenile trout appeared to prefer the borders of riffle areas for rearing. Juvenile rainbow trout and brown trout collected in the Darby section averaged 53 and 70 mm (2.1 and 2.8 in.), respectively, in total length. In the Tucker section, juvenile rainbow trout and brown trout averaged 60 and 89 mm (2.4 and 3.5 in.), respectively, in total length.

Tag distributions and movements by trout

A total of 1772 individually numbered Floy tags have been distributed in trout in the Bitterroot River (Table 17). The species tagged include 781 rainbow trout, 941 brown trout, 42 cutthroat trout and 8 bull trout. A majority of these tags were distributed in the Darby and Tucker sections.

Table 17. Distribution of tags for trout collected in the Bitterroot River from September, 1983 to November, 1984.

	Number of Tags Distributed				
Location	Rainbow trout	Brown trout	Cutthroat trout	Brook trout	Bull trout
Darby to Como bridge	205	122	13	0	4
Como bridge to Hamilton	61	24	2	0	1
Hamilton to Tucker	98	124	1	0	0
Tucker to Bell	359	544	16	0	3
Bell to Stevensville	58	127	10	0	0
Total	781	941	42	0	8

Movements of tagged trout recaptured in the Bitterroot River by electrofishing for the period from September, 1983 to November, 1984 are presented in Table 18. Movement was defined as those fish recaptured 2 or more kilometers (≤1.24 mi.) from their original tag site. Of 184 rainbow trout recaptured, 22 (12.0%) moved from their original site of capture. Distances moved ranged from 2.0 km (1.24 mi.) to 15.8 km (9.82 mi.). Thirty-four (10.9%) of 311 brown

Table 18. Movements of tagged trout recaptured by electrofishing in the Bitterroot River for the period September, 1983 to November, 1984.

Section	Trout Species	Upstream Movement			Downstream Movement			No Movement
		Number of Fish	Mean (km)	Range (km)	Number of Fish	Mean (km)	Range (km)	Number of Fish
Darby to Hamilton	Rainbow	5	4.2	2.3-5.6	4	3.5	2.0-7.2	73
	Brown	3	6.9	2.2-16.4	3	2.8	2.2-3.9	56
Hamilton to Stevensville	Rainbow	6	7.7	2.7-15.8	7	3.8	2.3-6.1	89
	Brown	10	5.1	2.0-11.8	18	4.5	2.0-11.5	221
Total	Rainbow	11	6.1	2.3-15.8	11	3.7	2.0-7.2	162
	Brown	13	5.5	2.0-16.4	21	4.3	2.0-11.5	277

trout recaptured by electrofishing moved from their original capture site. Movements by brown trout ranged from 2.0 km (1.24 mi.) to 16.4 km (10.2 mi.). Fewer recaptured trout moved upstream than moved downstream. There was no apparent relationship between movements by trout and their spawning season. These data are preliminary, however, since tagged fish have been at large only for a relatively short period of time. Harvest rates for tagged trout have not been computed since few tags have been returned by fisherman. A summary of tag returns will be presented in the final report.

Minimum flow recommendations

The quantification of instream flow needs for trout in the Bitterroot River is essential for directing the efficient management of supplemental water releases from Painted Rocks Reservoir. A wetted perimeter/inflection point method was used to determine minimum flow recommendations for the Darby and Tucker sections. Three riffle areas in the Darby section and three riffle areas near the Tucker section were utilized for analyses of minimum flows (Figure 1). Wetted perimeter data were obtained from three channel cross sections established at each riffle. Flow recommendations for a riffle were computed by averaging the wetted perimeter data predicted for associated flows of interest obtained at these three cross sections. Inflection point values for all riffles within each section were then averaged to obtain a final minimum flow recommendation.

Wetted perimeter - discharge relationships and associated inflection points obtained from the three riffles in the Darby section are presented in Appendix Figures 17-19. Discharge values from the lower inflection points derived for each riffle were averaged to obtain a final recommendation of flow. The lower inflection points were chosen because discharge values associated with the upper inflection points were substantially greater than median monthly flows derived from records at the U.S.G.S. station near Darby (Brown 1982). Minimum flow recommendations obtained from the three riffles in the Darby section averaged 8.5m^3/sec (300ft^3/sec). A 8.5m^3/sec (300ft^3/sec) recommendation for the Darby section is less than the median monthly flows for April through October recorded at the U.S.G.S. station near Darby.

Wetted perimeter-discharge relationships and associated inflection points obtained from two riffles near the Tucker section are presented in Appendix Figures 20 and 21. A third riffle area was excluded from analyses due to channel changes that occurred during the survey period. Minimum flow recommendations derived from the two riffles in the Tucker section averaged 10.6 m^3/sec (375 ft^3/sec). This minimum flow recommendation is seldom met within the dewatered reach of the river during the irrigation season. Supplemental water released from Painted Rocks Reservoir should be managed to meet this recommendation for the greatest possible amount of time. The quantity of supplemental water needed to maintain minimum flow recommendations has been discussed in the draft water management plan (Lere 1984).

DISCUSSION

A comparison of population estimates obtained in the Darby (control) and Tucker (dewatered) sections indicates historical dewatering has resulted in a reduction of the rainbow trout fishery in the Bitterroot River. Dewatering appeared to be the primary limiting factor for rainbow trout production since measurements of other habitat features were similar between the two sections. As a result, the release of supplemental water from Painted Rocks Reservoir, if not lost to irrigation withdrawals or natural phenomena, should raise the carrying capacity for rainbow trout within this dewatered reach.

The quantity of additional water required to maintain the recommended minimum flow within the dewatered reach was determined using a model derived to relate discharge monitored at the U.S.G.S. station near Darby to discharge at Bell crossing (Lere 1984). Modeling predicted that 15,000 acre feet of supplemental water (5,000 AF controlled by MFWP and 10,000 AF proposed purchase) could maintain a 10.6 m^3/sec (375 ft^3/sec) recommended minimum flow at Bell crossing approximately 53% of the time for the period from July 16 to September 30. During extremely dry years, this minimum flow recommendation may seldom be achieved regardless of supplemental water releases. However, 15,000 acre feet of supplemental water virtually insure flows at Bell would meet or exceed 2.83 m^3/sec (100 ft^3/sec). Although flows in the dewatered reach apparently cannot be maintained at recommended levels during all years, augmentation should enhance the trout fishery to some degree. However, trout populations within the dewatered section may never reach levels present in the reach of river that remains well watered.

Two years of augmented discharge is not a sufficient period of time for trout populations within the dewatered reach of the river to fully respond to supplemental water releases from Painted Rocks Reservoir. Hunt (1976) has shown that trout populations peaked 5 years after habitat development on a Wisconsin stream. Hunt concluded there commonly is a transition period between habitat treatment and maximum response by trout populations. To fully evaluate the effects of supplemental water on trout populations in the Bitterroot River, censusing should be continued during the next several years. Baseline data should continue to be gathered during 1985. Post-treatment data should be gathered following a 2 to 3 year transitional period to allow time for trout populations to fully respond to augmented flows. Discharge in the dewatered reach should be monitored continuously on a long term basis to maintain the appropriate release schedule for supplemental water and to evaluate the effectiveness of water releases in maintaining recommended instream flows.

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APPENDIX TABLES

APPENDIX TABLE 1. Mean daily flows[1] recorded at the Darby, Woodside and Bell stations on the Bitterroot River during 1983.

	JULY		SEPTEMBER			AUGUST			OCTOBER			NOVEMBER		
DAY	DARBY	BELL CROSSING	DARBY	WOODSIDE CROSSING	BELL CROSSING	DARBY	WOODSIDE CROSSING	BELL CROSSING	DARBY	WOODSIDE CROSSING	BELL CROSSING	DARBY	WOODSIDE CROSSING	BELL CROSSING
1	1470		502		708	436	439	400	445	762	722	348	627	668
2	1680		546			455	468	443	445	751	708	357	643	677
3	1480		526			454	473	460	440	729	692	356	641	696
4	1280		515		625	445	472	435	440	708	689	344	669	725
5	1170		492		553	429		397	456	766	733	373	819	897
6	1190		452			420	467	396	445	739	715	370	810	863
7	1200		421			411	464	387	440	700	673	436	1027	1068
8	1140		409			406	459	382	446	693	659	417	916	1016
9	1090		426		395	411	461	390	511	740	694	382	820	909
10	1840		544		374	409	462	398	515	921	870	377	789	839
11	1600		616		570	422	482	424	477	919	910	379	802	861
12	1330		553		653	417	603	484	450	839	847	400	839	917
13	1220	1631	499			370		461	450	794	804	394	802	
14	1250		479			367	471	429	469	812	814	384	781	
15	1210		474			423	508	425	449	829	828	374	735	
16	1060	1530	461			419	508	441	442	780	792			
17	943		450			413	477	442	441	756	768			
18	876	1332	430			417	516	490	443	769	764			
19	852	1273	417		450	450	625	601	436	751	765			
20	852		461			446	637	623	435	728	752			
21	840	1283	494			449	627	599	433	732	750			
22	748		521			445	633	598	433	728	750			
23	692	1067	550		595	445	621	591	453	809	812			
24	698		522			440	598	576	442	856	897			
25	692		508		566	430	575	554	435	783	833			
26	647		504			420	562	531	430	750	789			
27	588		487			425	553	532	421	717	765			
28	550	770	472			430	562	533	404	695	752			
29	515	716	462	542	487	425	566	534	361	663	750			
30	480		448	510	461	440	681	625	355	641	692			
31	463	532	440	470	425				351	625	672			

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[1] Flows at Bell crossing from July 13 to August 25 were derived from single observations of a staff gauge.

APPENDIX TABLE 2. Mean daily flows recorded at the Darby, Hamilton, Woodside and Bell stations on the Bitterroot River during 1984.

	JULY			AUGUST				SEPTEMBER				OCTOBER			
DAY	DARBY	WOODSIDE CROSSING	BELL CROSSING	DARBY	HAMILTON	WOODSIDE CROSSING	BELL CROSSING	DARBY	HAMILTON	WOODSIDE CROSSING	BELL CROSSING	DARBY	HAMILTON	WOODSIDE CROSSING	BELL CROSSING
1	3170			677		679	699	742	986	937	741		882	827	908
2	2970			665		678	674	604	809	789	802		885	839	923
3	2860			632		650	627	538	650	672	671		835	798	864
4	2620		4335	600		606	591	511	592	602	587		790	769	828
5	2550		4233	578		574	549	495	551	537	533		707	707	761
6	2440		4031	556		556	510	515	575	560	519		675	662	729
7	2290		3744	529		536	486	539	649	641	590		661	659	639
8	2050		3158	492		522	452	524	651	646	610		643	641	666
9	1860	2018	2728	458			415	596	1020	839	943		571	644	615
10	1720	1876	2380	429	394		381	531	798	841	855		541	609	563
11	1620	1796	2121	444	383	459	350	504	728	754	762		524	600	551
12	1590	1762	1966	632	495	560	378	488	664	684	688		553	600	562
13	1540	1546	1860	631	593	631	447	474	617	667	617		598	587	599
14	1360	1392	1646	613	590	622	437	465	641	680	590		616	557	654
15	1250	1299	1456	606	571	607	434	464	780	810	742		591	557	628
16	1150	1190	1339	586	581	616	441	463	764	780	750				
17	1090		1213	429	489	566	427	458	736	737	718				
18	1080		1162	427	417	477	373	451	695	701	652				
19	1090		1152	519	465	487	374	439	658	671	581				
20	1010		1098	506	480	498	389	450	692	709	610				
21	907		961	496	457	457	378	538	1108	983	970				
22	837		860	490	445	436	366	501	1026	1084	1075				
23	820		804	487	428	420	368	496	1026	1053	1074				
24	818		778	478	433	434	381	492	999	1066	1051				
25	819		729	471	426	414	368	478	917	959	978				
26	788		671	462	419	408	356	485	881	924	925				
27	834		764	456	401	385	338	490	931	883	974				
28	792		786	444	385	375	321	474	934	882	973				
29	819		796	438	374	368	311	463	908	871	943				
30	808		819	439	373	393	315	460	878	845	903				
31	708	707	778	598	609	611	469								

APPENDIX TABLE 3. Daily maximum and minimum water temperatures (^{O}F) recorded at the Darby Station on the Bitterroot River during 1984.

	Daily			Daily			Daily			Daily			Daily			Daily			Daily	
DATE	Max.	Min.	DATE	Max.	Min.	DATE	Max.	Min.	DATE	Max.	Min.	DATE	Max.	Min.	DATE	Max.	Min.	DATE	Max.	Min.
03/03/84	39	33.5	04/03/84	44	35	05/04/84	47	39	06/04/84	45.5	43	07/05/84	62	52.5	08/05/84			09/05/84	59	54
03/04/84	39	33	04/04/84	46	37.5	05/05/84	46	40.5	06/05/84	48.5	43	07/06/84	58.5	54	08/06/84	64.5	56	09/06/84	57.5	53.5
03/05/84	35	32	04/05/84	44.5	40	05/06/84	46	38.5	06/06/84	47	43.5	07/07/84	60.5	52	08/07/84	64.5	56	09/07/84	56.5	50
03/06/84	39	32	04/06/84	41.5	38	05/07/84	50.5	38	06/07/84	48	42	07/08/84	60	51	08/08/84	65.5	55.5	09/07/84	58	51
03/07/84	40	33	04/07/84	44	35	05/08/84	52	41.5	06/08/84	48	43	07/09/84	60	51	08/09/84	66.5	56.5	09/09/84	59	51.5
03/08/84	38.5	33	04/08/84	41	38.5	05/09/84	50	45	06/09/84	48	43	07/10/84	62	51.5	08/10/84	64	57	09/10/84	58.5	51
03/09/84	41	36.5	04/09/84	45	37	05/10/84	46	41.5	06/10/84	45	43	07/11/84	63	53	08/11/84	63	57.5	09/11/84	55.5	51
03/10/84	39.5	36	04/10/84	42.5	38.5	05/11/84	49	42	06/11/84	47.5	43	07/12/84	64	55	08/12/84	62	54	09/12/84	56	50
03/11/84	41	36	04/11/84	42	36.5	05/12/84	51.5	43	06/12/84	49	43	07/13/84	63	53.5	08/13/84	62	53	09/13/84	56	48
03/12/84	40.5	36	04/12/84	42	37	05/13/84	49	41	06/13/84	48.5	44	07/14/84	63	53.5	08/14/84	61	52.5	09/14/84	56	48
03/13/84	37	34	04/13/84	47.5	37	05/14/84	46	41.5	06/14/84	51	44	07/15/84	64	54	08/15/84	60	53	09/15/84	57	49.5
03/14/84	38.5	35	04/14/84	49.5	38	05/15/84	42	39	06/16/84	49	44	07/16/84	65	54	08/16/84	59	54.5	09/16/84	58.5	51
03/15/84	38.5	34	04/15/84	51	40	05/16/84	44	40	06/16/84	51.5	45	07/17/84	65.5	55	08/17/84	64	54	09/17/84	60	51.5
03/16/84	40.5	36	04/16/84	49	40	05/17/84	48	39	06/17/84	51	43	07/18/84	62	57	08/18/84	63	56.5	09/18/84	60.5	52
03/17/84	39	36	04/17/84	44	39	05/18/84	48	41	06/18/84	52	44	07/19/84	64.5	56	08/19/84	62	55	09/19/84	59	53
03/18/84	41	35	04/18/84	43.5	39.5	05/19/84	47	42	06/19/84	51	45.5	07/20/84	62	56	08/20/84	60.5	51	09/29/84	58	54.5
03/19/84	42.5	37	04/19/84	44	39	05/20/84	46	42.5	06/20/84	50	45	07/21/84	61.5	55	08/21/84	61	51	09/21/84	56	50
03/20/84	45.5	38.5	04/20/84	41	38.5	05/21/84	45	40.5	06/21/84	48	45	07/22/84	63.5	54.5	08/22/84	61	52	09/22/84	50	46.5
03/21/84	41	37.5	04/21/84	44	38	05/22/84	48	40	06/22/84	50	44	07/23/84	61.5	57	08/23/84	60.5	54	09/23/84	48	45
03/22/84	40	36	04/22/84	48	39	05/23/84	45.5	42.5	06/23/84	53	44	07/24/84	66.5	56	08/24/84	60	53	09/24/84	47	43
03/23/84	41	35	04/23/84	46	40	05/24/84	44.5	40.5	06/24/84	54	46	07/25/84	68.5	57.5	08/24/84	59	53	09/25/84	49	42
03/24/84	41	37	04/24/84	41	36	05/25/84	48	40	06/25/84	55	48	07/26/84	66.5	59	08/26/84	61	53	09/26/84	47	45.5
03/25/84	39	35	04/25/84	39	36.5	05/26/84	48	43	06/26/84	54	47.5	07/27/84	67.5	60	08/27/84	59.5	53	09/27/84	47	43.5
03/26/84	41	35	04/26/84	39	35.5	05/27/84	50	42	06/27/84	55.5	47.5	07/28/84	65	60.5	08/28/84	62	54	09/28/84	49	43
03/27/84	42	36.5	04/27/84	44	35	05/28/84	51	42	06/28/84	57	48	07/29/84	64.5	59	08/29/84	61	52.5	09/29/84	49	42
03/28/84	39	34.5	04/28/84	41	35	05/29/84	53	43.5	06/29/84	56.5	50	07/30/84	66	56.5	08/30/84	58	53	09/30/84	50	43
03/29/84	41.5	36	04/29/84	43.5	37	05/30/84	49.5	44.5	06/30/84	54	46.5	07/31/84	66	57.5	08/31/84	55.5	53.5	10/01/84	51	45
03/30/84	43.5	37	04/30/84	44.5	36.5	05/31/84	47.5	42.5	07/01/84	56.5	46.5	08/01/84	64	59.5	09/01/84	58	52	10/02/84	51	44.5
03/31/84	46	36.5	05/01/84	47	39	06/01/84	49	41	07/02/84	59	49	08/02/84	65	57.5	09/02/84	59	50	10/03/84	52	45
04/01/84	46	39	05/02/84	47.5	44	06/02/84	48	42	07/03/84	59	50.5	08/03/84	63	57	09/03/84	57	51	10/04/84	52	45.5
04/02/84	43.5	36	05/03/84	49	41	06/03/84	48	44	07/04/84	61	52	08/04/84	65	57	09/04/84	61	51.5			

APPENDIX TABLE 4. Daily maximum and minimum water temperatures (^{o}F) recorded at the Hamilton Station on the Bitterroot River during 1984.

DATE	Daily Max.	Daily Min.	DATE	Daily Max.	Daily Min.	DATE	Daily Max.	Daily Min.	DATE	Daily Max.	Daily Min.	DATE	Daily Max.	Daily Min.	DATE	Daily Max.	Daily Min.	DATE	Daily Max.	Daily Min.
03/02/84	41.5	37	04/02/84	46	40	05/03/84	53	45	06/03/84	51	46	07/04/84	61	53.5	08/04/84	68	60	09/04/84	64	55
03/03/84	41	36	04/03/84	47	39	05/04/84	51	43.5	06/04/84	48	45	07/05/84	62	54	08/05/84	68	60	09/05/84	62.5	56.5
03/04/84	41	35	04/04/84	51	41	05/05/84	48	44	06/05/84	50.5	44.5	07/06/84	61	55	08/06/84	68.5	59	09/06/84	60.5	55
03/05/84	37	34	04/05/84	49	43.5	05/06/84	48.5	42	06/06/84	49	45	07/07/84	60.5	53	08/07/84	69	59	09/07/84	58	51
03/06/84	41	33	04/06/84	45	41	05/07/84	53.5	42	06/07/84	50	44	07/08/84	60.5	53	08/08/84	69.5	59	09/08/84	58.5	52
03/07/84	43	35	04/07/84	48	38	05/08/84	56	45	06/08/84	50	45	07/09/84	61	54	08/09/84	71	60	09/09/84	59	52
03/08/84	42.5	36	04/08/84	44	41.5	05/09/84	55.5	49.5	06/09/84	49.5	45	07/10/84	62	54	08/10/84	69	60	09/10/84	60	52.5
03/09/84	43.5	39.5	04/09/84	47	39	05/10/84	50	46	06/10/84	47	45	07/11/84	64	55.5	08/11/84	66	61	09/11/84	57.5	53
03/10/84	42.5	39	04/10/84	45	41	05/11/84	53	45	06/11/84	49	45	07/12/84	65	58	08/12/84	66.5	60	09/12/84	56	51
03/11/84	44	38.5	04/11/84	46.5	39	05/12/84	53	47	06/12/84	52	45	07/13/84	64	57	08/13/84	68	59	09/13/84	57	49.5
03/12/84	43	39	04/12/84	47	39	05/13/84	53	45	06/13/84	50	46.5	07/14/84	64.5	56	08/14/84	67.5	58.5	09/14/84	57	49
03/13/84	40	37	04/13/84	50.5	40	05/14/84	51	46	06/14/84	53.5	46	07/15/84	66	57	08/15/84	66	59.5	09/15/84	58	50.5
03/14/84	41.5	38	04/14/84	53	41.5	05/15/84	46	41.5	06/15/84	52.5	47	07/16/84	66.5	57.5	08/16/84	63.5	60	09/16/84	60.5	52
03/15/84	41	37	04/15/84	56	45	05/16/84	45.5	41	06/16/84	54	47	07/17/84	68	58.5	08/17/84	67	57	09/17/84	62	53.5
03/16/84	43.5	38.5	04/16/84	55.5	46.5	05/17/84	49	40.5	06/17/84	53	46	07/18/84	62.5	59	08/18/84	67.5	60	09/18/84	63	55
03/17/84	41.5	38	04/17/84	49	45	05/18/84	50	43.5	06/18/84	54.5	47	07/19/84	67.5	58	08/19/84	68	60.5	09/19/84	61	55
03/18/84	43	37	04/18/84	45.5	43.5	05/19/84	49	45	06/19/84	53	48.5	07/20/84	64	59	08/20/84	66	57	09/20/84	60	56
03/19/84	45	39	04/19/84	45.5	42	05/29/84	48	44	06/20/84	53	48	07/21/84	64.5	56.5	08/21/84	66	56	09/21/84	57	51.5
03/20/84	47.5	41	04/20/84	42	41	05/21/84	47	42	06/21/84	51	48	07/22/84	65	56.5	08/22/84	65	57	09/22/84	51.5	47.5
03/21/84	45.5	41	04/21/84	46.5	40	05/22/84	49	41.5	06/22/84	51.5	46	07/23/84	65	59	08/23/84	65	59	09/23/84	49.5	45
03/22/84	42.5	39	04/22/84	51	42.5	05/23/84	48.5	45	06/23/84	53	47	07/24/84	68	58	08/24/84	64.5	58	09/24/48	48	44
03/23/84	43	37	04/23/84	49	44	05/24/84	45.5	41.5	06/24/84	55	49	07/25/84	71	61	08/25/84	63.5	57	09/25/84	49.5	43
03/24/84	45	37	04/24/84	43.5	40	05/25/84	49	41.5	06/25/84	57.5	51	07/26/84	71	62.5	08/26/84	67	57.5	09/26/84	49	46
03/25/84	41.5	38	04/25/84	42	39	05/26/84	49.5	44.5	06/26/84	57	50	07/27/84	68	62	08/27/84	65	58.5	09/27/84	48	44
03/26/84	41	37	04/26/84	40.5	37	05/27/84	52	44	06/27/84	58	52	07/28/84	68	63	08/28/84	64.5	58	09/28/84	50	44
03/27/84	44.5	38	04/27/84	45	36.5	05/28/84	52	45	06/28/84	59	51	07/29/84	66.5	61	08/29/84	66	57	09/29/84	49.5	43
03/28/84	41.5	37	04/28/84	44	38	05/29/84	54.5	47	06/29/84	58	53	07/30/84	68	58.5	08/30/84	62	58	09/30/84	51	44
03/29/84	44	37.5	04/29/84	47.5	39	05/30/84	54	48	06/30/84	56	49	07/31/84	69	60	08/31/84	59	56.5	10/01/84	52.5	45.5
03/30/84	45	39	04/30/84	48.5	40	05/31/84	49.5	44.5	07/01/84	58	50	08/01/84	65	61	09/01/84	60	54	10/02/84	52.5	46
03/31/84	47.5	39	05/01/84	51	43	06/01/84	50	43	07/02/84	59.5	52	08/02/84	69	59.5	09/02/84	62	53.5	10/03/84	53	46
04/01/84	48	41	05/02/84	53	45	06/02/84	48.5	44	07/03/84	59	52	08/03/84	69	60	09/03/84	62	54.5	10/04/84	53.5	47

APPENDIX TABLE 5. Daily maximum and minimum water temperatures (°F) recorded at the Bell Station on the Bitterroot River during 1984.

	Daily			Daily			Daily			Daily			Daily			Daily			Daily			Daily	
DATE	Max.	Min.	DATE	Max.	Min.	DATE	Max.	Min.	DATE	Max.	Min.	DATE	Max.	Min.	DATE	Max.	Min.	DATE	Max.	Min.	DATE	Max.	Min.
03/07/84	44.5	37	04/07/84	49.5	40	05/08/84	56.5	46	06/08/84			07/09/84	64.5	56	08/09/84	71	61	09/09/84	60	56	10/10/84	57	53
03/08/84	43.5	38	04/08/84	45.5	43.5	05/09/84	56.5	50	06/09/84			07/10/84	65	56	08/10/84	68.5	61.5	09/10/84	61.5	55	10/11/84	55	53
03/09/84	46	41	04/09/84	48.5	41	05/10/84	52	48	06/10/84			07/11/84	66	56.5	08/11/84	66	61.5	09/11/84	59.5	55.5	10/12/84	54	51
03/10/84	45	40	04/10/84	46.5	42.5	05/11/84	53	47	06/11/84			07/12/84	67	58	08/12/84	66.5	60	09/12/84	59	54.5	10/13/84	53	51
03/11/84	44.5	41	04/11/84	48.5	41	05/12/84	55	49	06/12/84			07/13/84	67	57.5	08/13/84	69	60	09/13/84	59	53	10/14/84	52	49.5
03/12/84	44	40	04/12/84	47	41	05/13/84	55	47	06/13/84			07/14/84	67	57.5	08/14/84	69.5	60	09/14/84	60	53	10/15/84	48	46
03/13/84	42	39	04/13/84	53	42.5	05/14/84	52	47.5	06/14/84			07/15/84	68	58	08/15/84	68	61	09/15/84	60	54	10/16/84		
03/14/84	43	39.5	04/14/84	54	43	05/15/84	47.5	42	06/15/84			07/16/84	69	59	08/16/84	65	61	09/16/84	62	55	10/17/84		
03/15/84	42.5	39	04/15/84	57	46	05/16/84	47	41.5	06/16/84			07/17/84	70	59.5	08/17/84	69	59.5	09/17/84	63	56	10/18/84		
03/16/84	45.5	40	04/16/84	57	48	05/17/84	49.5	42	06/17/84			07/18/84	65	60	08/18/84	69	61	09/18/84	63.5	57	10/19/84		
03/17/84	43	40	04/17/84	52	46	05/18/84	51	45.5	06/18/84			07/19/84	68	58	08/19/84	69	61.5	09/19/84	61.5	57	10/20/84		
03/18/84	43.5	38.5	04/18/84	48.5	45	05/19/84	50	47	06/19/84			07/20/84	65	60	08/20/84	68	59	09/20/84	60	57.5			
03/19/84	46	40.5	04/19/84	47.5	44	05/20/84	49	46	06/20/84			07/21/84	66	58	08/21/84	68	59	09/21/84	57	54			
03/20/84	49	43	04/20/84	45	42.5	05/21/84	46	43	06/21/84			07/22/84	66	57.5	08/22/84	67	59	09/22/84	55	52			
03/21/84	47	43.5	04/21/84	48.5	41.5	05/22/84	50	43	06/22/84			07/23/84	65	59	08/23/84	67	60.5	09/23/84	52	50.5			
03/22/84	44.5	41	04/22/84	52.5	44	05/23/84			06/23/84			07/24/84	68	59	08/24/84	67	60	09/24/84	52.5	48.5			
03/23/84	44	38	04/23/84	50	45.5	05/24/84			06/24/84			07/24/84	71	61	08/24/84	65	59.5	09/25/84	54	49.5			
03/24/84	45	41	4/24/84	46	42	05/25/84			06/25/84			07/26/84	72	63	08/26/84	68	58.5	09/26/84	53	51.5			
03/25/84	43	40	04/25/84	46	39.5	05/26/84			06/26/84			07/27/84	69	63	08/27/84	67	60	09/27/84	52	49.5			
03/26/84	43.5	39	04/26/84	41.5	39	05/27/84			06/27/84			07/28/84	68	62.5	08/28/84	65	59	09/28/84	55	49			
03/27/84	45	39	04/27/84	47.5	38	05/28/84			06/28/84	61	55	07/29/84	68	62	08/29/84	66	58	09/29/84	54.5	50			
03/28/84	43	39	04/28/84	46	40	05/29/84			06/29/84	60	56	07/30/84	69	59.5	08/30/84	62	59	09/30/84	55	50			
03/29/84	46	39.5	04/29/84	49.5	40	05/30/84			06/30/84	59	53	07/31/84	70	61	08/31/84	60	58	10/01/84	56	51			
03/30/84	47	40.5	04/30/84	50.5	41.5	05/31/84			07/01/84	60	53	08/01/84	66.5	62	09/01/84	62	56	10/02/84	56	52			
03/31/84	49.5	40.5	05/01/84	52	45	06/01/84			07/02/84	62	55	08/02/84	70	60.5	09/02/84	64	56	10/03/84	56.5	52			
04/01/84	49	41.5	05/02/84	53.5	46	06/02/84			07/03/84	62	55	08/03/84	71	61	09/03/84	63	57	10/04/84	56.5	52			
04/02/84	49	42	05/03/84	53	46.5	06/03/84			07/04/84	63.5	56	08/04/84	70	61.5	09/04/84	65.5	57	10/05/84	58	54			
04/03/84	49	40	05/04/84	52	45	06/04/84			07/05/84	64	56.5	08/05/84	68	61	09/05/84	64	58.5	10/06/84	55	52			
04/04/84	51	42.5	05/05/84	49.5	45	06/05/84			07/06/84	63.5	57.5	08/06/84	69	60.5	09/06/84	61.5	57	10/07/84	57	52.5			
04/05/84	51	45	05/06/84	49	42.5	06/06/84			07/07/84	63	55	08/07/84	70	60	09/07/84	58.5	54	10/08/84	57	52.5			
04/06/84	48.5	44.5	05/07/84	55	42.5	06/07/84			07/08/84	63.5	55	08/08/84	70	60	09/08/84	61	55	10/09/84	57	53			

APPENDIX TABLE 6. Daily maximum and minimum water temperatures (^{o}F) recorded at the McClay Station on the Bitterroot River during 1984.

DATE	Daily Max.	Daily Min.	DATE	Daily Max.	Daily Min.	DATE	Daily Max.	Daily Min.	DATE	Daily Max.	Daily Min.	DATE	Daily Max.	Daily Min.	DATE	Daily Max.	Daily Min.	DATE	Daily Max.	Daily Min.	DATE	Daily Max.	Daily Min.
03/07/84	44	39	04/07/84	47	43	05/08/84	53.5	50	06/08/84	52	48	07/09/84	62	58	08/09/84	71	66	09/09/84	62	60	10/10/84	55.5	53.5
03/08/84	44	41	04/08/84	47	45	05/09/84	55	52	06/09/84	52	48	07/10/84	65	60.5	08/10/84	70	67	09/10/84	62	59	10/11/84	55	51.5
03/09/84	46.5	43	04/09/84	47	43.5	05/10/84	52	51	06/10/84	51	48	07/11/84	66	61.5	08/11/84	69	65.5	09/11/84	62	59.5	10/12/84	52.5	50.5
03/10/84	46	43	04/10/84	47	45	05/11/84	53	49.5	06/11/84	50.5	48	07/12/84	66.5	63	08/12/84	68	64.5	09/12/84	58	56	10/13/84	51.5	49.5
03/11/84	44	43.5	04/11/84	47	44	05/12/84	53.5	51	06/12/84	55	48	07/13/84	66.5	62	08/13/84	68.5	64	09/13/84	57	54.5	10/14/84	50	48
03/12/84	45.5	42.5	04/12/84	46.5	44	05/13/84	55	50	06/13/84	55	51	07/14/84	66.5	62.5	08/14/84	69	65	09/14/84		54.5	10/15/84		47
03/13/84	43	42	04/13/84	50.5	45	05/14/84	55	51	06/14/84	56	50	07/15/84	67.5	63.5	08/15/84	69.5	67	09/15/84					
03/14/84	43.5	42	04/14/84	51.5	47.5	05/15/84	51	45	06/15/84	56	51.5	07/16/84	68	64.5	08/16/84	69	66	09/16/84					
03/15/84	43	42	04/15/84	54	49.5	05/16/84	47	43	06/16/84	56	51	07/17/84	69	65	08/17/84	69.5	64	09/17/84					
03/16/84	44	42	04/16/84	55	52	05/17/84	50	44	06/17/84	55.5	51	07/18/84	69	64	08/18/84	69	66	09/18/84					
03/17/84	43	42.5	04/17/84	55	50	05/18/84	52	47	06/18/84	56	51.5	07/19/84	68	63.5	08/19/84	69.5	66	09/19/84					
03/18/84	43	41.5	04/18/84	50	46.5	05/19/84	52	48	06/19/84	56	52	07/20/84	68	64.5	08/20/84	68	65	09/20/84					
03/19/84	45	42.5	04/19/84	49	46	05/20/84	51	48	06/20/84	57	52	07/21/84	66	63	08/21/84	68	64	09/21/84	58	54			
03/20/84	48.5	45	04/20/84	47.5	45	05/21/84	49	45	06/21/84	56	52	07/22/84	66	62	08/22/84	68.5	65	09/22/84	54	52.5			
03/21/84	48	46	04/21/84	48	43	05/22/84	50.5	44.5	06/22/84	54	50	07/23/84	66	63.5	08/23/84	68	65.5	09/23/84	52.5	49			
03/22/84	46	44	04/22/84	51.5	46	05/23/84	51	48	06/23/84	57	51	07/24/84	68	64	08/24/84	67.5	65	09/24/84	50	47			
03/23/84	44	42	04/23/84	51	48	05/24/84	49	45	06/24/84	58.5	53	07/25/84	70.5	66.5	08/25/84	67	64	09/25/84	51	48			
03/24/84	45	43.5	04/24/84	50	45	05/25/84	50	44.5	06/25/84	60	55	07/26/84	71	68.5	08/26/84	68	63	09/26/84					
03/25/84	44.5	43	04/25/84	45.5	42.5	05/26/84	51	48	06/26/84	59	54	07/27/84	70	67	08/27/84	68	64.5	09/27/84					
03/26/84	43	41.5	04/26/84	45	41	05/27/84	53	48	06/27/84	60	55	07/28/84	69	67	08/28/84	66	63	09/28/84	51	47.5			
03/27/84	43.5	42	04/27/84	46	40	05/28/84	54	49	06/28/84	60.5	55	07/29/84	68	66	08/29/84	67	61.5	09/29/84	51.5	48.5			
03/28/84	44	42	04/28/84	46	43	05/29/84	56	50	06/29/84	60	56	07/30/84	68.5	65	08/30/84	65	62	09/30/84	52	49			
03/29/84	46	42	04/29/84	48	44	05/30/84	56	51.5	06/30/84	58	54	07/31/84	70	66	08/31/84	62.5	61	10/01/84	53	51			
03/30/84	46	43.5	04/30/84	50	46	05/31/84	53	47.5	07/01/84	59	54	08/01/84	70	67	09/01/84	64	59.5	10/02/84					
03/31/84	48	44	05/01/84	52	49	06/01/84	51	46	07/02/84	61	55.5	08/02/84	70	65	09/02/84	64	61	10/03/84					
04/01/84	48	45	05/02/84	52	49.5	06/02/84	51	47	07/03/84	61	56	08/03/84	70	67	09/03/84	64	61.5	10/04/84	54.5	52			
04/02/84	47.5	45	05/03/84	52	49	06/03/84	53	48	07/04/84	62.5	57	08/04/84	69.5	66.5	09/04/84	66	62	10/05/84	56	53.5			
04/03/84	47.5	45	05/04/84	51.5	49	06/04/84	53	48	07/05/84	63	58	08/05/84	69	66.5	09/05/84	65.5	63	10/06/84	55	53			
04/04/84	50	46	05/05/84	50	48	06/05/84	52	47	07/06/84	62.5	58.5	08/06/84	68	65	09/06/84	64.5	61	10/07/84	55	52			
04/05/84	50	48	05/06/84	48	46	06/06/84	52	48.5	07/07/84	61.5	57	08/07/84	68	65	09/07/84	61	57.5	10/08/84	55	53			
04/06/84	49	45	05/07/84	52	46	06/07/84	51.5	47	07/08/84	62	57	08/08/84	69.5	65	09/08/84	60	57	10/09/84	55	53			

APPENDIX TABLE 7. Measurements of pH in the Bitterroot River and irrigation returns during 1983 and 1984.

	BITTERROOT RIVER[1]						IRRIGATION RETURNS[1]			
	1		2		3		4		5	
DATE	LAB	FIELD	LAB	FIELD	LAB	FIELD	LAB	FIELD	LAB	FIELD
(1983)										
9/15	—	7.8	—	—	—	8.4	—	—	—	—
10/31	8.0	7.4	8.0	8.0	8.1	8.6	—	—	8.3	8.8
11/16	7.7	7.8	7.9	8.1	8.1	8.3	—	—	8.4	8.2
(1984)										
7/9	7.6	6.5	7.7	6.5	7.8	6.6	9.3	8.4	8.4	6.7
7/25	7.6	6.5	7.8	6.6	7.9	6.6	8.7	6.8	8.1	6.6
8/9	7.6	6.5	7.8	6.6	8.0	6.6	8.6	7.2	8.1	6.6
8/27	7.5	6.7	7.9	6.6	8.2	6.6	9.1	7.4	8.1	6.8
9/12	7.6	6.5	7.9	6.7	8.1	6.9	8.6	6.9	8.1	6.9
9/26	7.5	6.4	7.7	6.7	7.8	6.7	8.0	6.9	7.9	6.9
10/15	7.5	6.9	7.8	7.8	8.0	7.8	8.4	8.0	8.3	7.8
10/30	7.5	6.7	7.8	7.0	8.0	7.0	8.4	7.1	8.0	6.9

[1] 1 Bitterroot River near Darby
2 Bitterroot River 4.8 km above bridge at Stevensville
3 Bitterroot River at bridge at Stevensville
4 Irrigation return 1.5 km above Victor crossing
5 Irrigation return 4.8 km above bridge at Stevensville

APPENDIX TABLE 8. Measurements of bicarbonate (mg/l) in the Bitterroot River and irrigation returns during 1984.

	BITTERROOT RIVER[1]			IRRIGATION RETURNS[1]	
	1	2	3	4	5
(1984)					
7/9	26.9	26.9	37.8	90.2	148.6
7/25	32.4	48.4	65.0	127.4	149.8
8/9	41.4	61.0	82.0	147.4	161.0
8/27	40.8	71.0	93.6	122.5	170.8
9/12	44.6	62.9	84.2	140.0	158.2
9/26	44.6	54.2	69.7	78.5	152.6
10/15	43.8	61.8	75.4	116.0	168.2
10/30	50.8	62.2	75.6	123.4	174.8

[1] Stations
1 Bitterroot River near Darby
2 Bitterroot River 4.8 km above bridge at Stevensville
3 Bitterroot River at bridge at Stevensville
4 Irrigation return 1.5 km above Victor crossing
5 Irrigation return 4.8 km above bridge at Stevensville

APPENDIX TABLE 9. Measurement of total nitrogen (mg/l) in the Bitterroot River and irrigation returns during 1984.

	BITTERROOT RIVER[1]			IRRIGATION RETURNS[1]	
	1	2	3	4	5
(1984)					
7/9	0.37	0.37	0.41	1.83	1.55
7/25	0.40	0.30	0.42	0.97	0.90
8/9	0.68	0.22	0.19	0.48	0.38
8/27	0.46	0.30	0.24	0.52	0.65
9/12	0.49	0.22	0.25	0.38	0.60
9/26	0.56	0.24	0.22	0.14	0.72
10/15	—	0.12	0.20	0.28	0.52
10/30	0.47	0.23	0.16	0.22	0.71

[1] Stations
1 Bitterroot River near Darby
2 Bitterroot River 4.8 km above bridge at Stevensville
3 Bitterroot River at bridge at Stevensville
4 Irrigation return 1.5 km above Victor crossing
5 Irrigation return 4.8 km above bridge at Stevensville

APPENDIX TABLE 10. Measurements of nitrate nitrogen (mg/l) in the Bitterroot River and irrigation returns during 1984

	BITTERROOT RIVER[1]			IRRIGATION RETURNS[1]	
	1	2	3	4	5
(1984)					
7/9	0.003	0.003	0.020	0.022	0.332
7/25	0.011	0.014	0.049	0.162	0.319
8/9	0.013	0.016	0.051	0.173	0.475
8/27	0.026	0.020	0.043	0.016	0.237
9/12	0.010	0.012	0.017	0.050	0.148
9/26	0.009	0.008	0.023	<0.001	0.145
10/15	0.009	0.018	0.012	0.006	0.114
10/30	0.017	0.007	0.019	0.058	0.226

[1] Stations
1 Bitterroot River near Darby
2 Bitterroot River 4.8 km above bridge at Stevensville
3 Bitterroot River at bridge at Stevensville
4 Irrigation return 1.5 km above Victor crossing
5 Irrigation return 4.8 km above bridge at Stevensville

APPENDIX TABLE 11. Measurement of total ammonia (mg/l) in the Bitterroot River and irrigation returns during 1983 and 1984.

	BITTERROOT RIVER[1]			IRRIGATION RETURNS[1]	
	1	2	3	4	5
(1983)					
9/15	---	---	---	---	---
10/27-31	0.02	<0.01	0.01	---	0.02
11/16-18	<0.01	<0.01	0.02	---	0.01
(1984)					
7/9	<.01	<.01	<.01	<.01	<.01
7/25	<.01	.01	.05	<.01	.16
8/9	<.01	<.01	.02	.02	.05
8/27	<.01	<.01	<.01	<.01	<.01

[1] Stations
1 Bitterroot River near Darby
2 Bitterroot River 4.8 km above bridge at Stevensville
3 Bitterroot River at bridge at Stevensville
4 Irrigation return 1.5 km above Victor crossing
5 Irrigation return 4.8 km above bridge at Stevensville

APPENDIX TABLE 12. Measurements of total phosphorus (mg/l) in the Bitterroot River and irrigation returns during 1984.

	BITTERROOT RIVER[1]			IRRIGATION RETURNS[1]	
	1	2	3	4	5
(1984)					
7/9	0.016	0.016	0.025	0.040	0.048
7/25	0.022	0.022	0.024	0.062	0.058
8/29	0.024	0.033	0.044	0.112	0.095
8/27	0.012	0.017	0.022	0.040	0.045
9/12	0.010	0.016	0.020	0.037	0.038
9/25	0.011	0.013	0.016	0.012	0.030
10/15	0.012	0.013	0.015	0.011	0.037
10/30	0.012	0.009	0.014	0.012	0.040

[1] Stations
1 Bitterroot River near Darby
2 Bitterroot River 4.8 km above bridge at Stevensville
3 Bitterroot River at bridge at Stevensville
4 Irrigation return 1.5 km above Victor crossing
5 Irrigation return 4.8 km above bridge at Stevensville

APPENDIX 13. Measurements of conductivity (u mhos/cm) in the Bitterroot River and irrigation returns during 1983 and 1984.

	BITTERROOT RIVER[1]			IRRIGATION RETURNS[1]	
	1	2	3	4	5
(1983)					
9/15	---	---	---	---	---
10/31	78	100	118	---	278
11/16	75	91	110	---	264
(1984)					
7/9	37	37	54	133	242
7/25	71	99	123	217	253
8/9	80	112	149	282	282
8/27	72	124	158	211	295
9/12	67	99	130	225	262
9/26	92	99	121	136	262
10/15	81	107	126	191	278
10/30	93	108	130	204	292

[1] Stations
1 Bitterroot River near Darby
2 Bitterroot River 4.8 km above bridge at Stevensville
3 Bitterroot River at bridge at Stevensville
4 Irrigation return 1.5 km above Victor crossing
5 Irrigation return 4.8 km above bridge at Stevensville

APPENDIX TABLE 14. Measurements of dissolved oxygen (mg/l) in the Bitterroot River and irrigation returns during 1983 and 1984.

	BITTERROOT RIVER[1]			IRRIGATION RETURNS[1]	
	1	2	3	4	5
(1983)					
9/15	9.30	---	10.50	---	---
10/31	9.80	10.80	11.20	---	12.80
11/16	11.35	11.50	11.50	---	11.95
(1984)					
7/9	9.40	8.30	8.90	13.35	12.60
7/25	8.85	8.40	9.30	12.10	11.50
8/9	8.25	7.55	9.10	11.70	11.30
8/27	9.70	8.60	8.60	13.75	11.30
9/12	9.50	9.25	10.10	12.45	11.90
9/26	9.80	9.60	9.60	9.90	10.10
10/15	10.25	10.25	10.90	13.15	10.90
10/30	11.20	11.60	11.70	14.20	12.30

[1] Stations
1 Bitterroot River near Darby
2 Bitterroot River 4.8 km above bridge at Stevensville
3 Bitterroot River at bridge at Stevensville
4 Irrigation return 1.5 km above Victor crossing
5 Irrigation return 4.8 km above bridge at Stevensville

APPENDIX TABLE 15. Measurements of total alkalinity (mg/l as $CaCo_3$) in the Bitterroot River and irrigation returns during 1983 and 1984.

	BITTERROOT RIVER[1]			IRRIGATION RETURNS[1]	
	1	2	3	4	5
(1983)					
9/15	44	---	77	---	---
10/31	50	50	57	---	138
11/16	50	55	60	---	117
(1984)					
7/9	26	24	30	75	127
7/25	34	43	64	119	134
8/9	36	53	75	140	53
8/27	20	43	43	73	118
9/12	32	45	55	90	120
9/26	50	50	50	67	110
10/15	37	---	50	90	50
10/30	44	50	62	98	137

[1] Stations
1 Bitterroot River near Darby
2 Bitterroot River 4.8 km above bridge at Stevensville
3 Bitterroot River at bridge at Stevensville
4 Irrigation return 1.5 km above Victor crossing
5 Irrigation return 4.8 km above bridge at Stevensville

APPENDIX TABLE 16. Catch statistics for trout collected in the Darby and Tucker sections of the Bitterroot River during the fall of 1983. Range in parentheses.

SECTION	SPECIES	MARKED	CAPTURED	RECAPTURED	MEAN LENGTH (MM)	MEAN WEIGHT (GM)
Darby	Rainbow Trout	341	381	30	281 (59-435)	288 (7-950)
	Brown Trout	241	227	36	282 (60-575)	361 (7-1921)
	Cutthroat Trout	16	31	3	327 (221-446)	318 (106-957)
	Brook Trout	34	23	1	204 (95-283)	103 (7-241)
	Bull Trout	6	5	0	277 (183-339)	228 (50-390)
Tucker (East Channel)	Rainbow Trout	175	126	32	322 (75-478)	443 (7-1013)
	Brown Trout	215	230	63	323 (85-579)	494 (7-1935)
	Cutthroat Trout	1	2	0	302 (281-314)	324 (241-369)
	Brook Trout	1	4	0	271 (218-349)	273 (106-524)
Tucker (West Channel)	Rainbow Trout	95	86	16	309 (70-465)	378 (7-928)
	Brown Trout	221	183	54	339 (81-737)	548 (7-3629)
	Cutthroat Trout	5	6	1	317 (260-410)	374 (191-737)
	Brook Trout	1	0	0	131 ---	28 ---
	Bull Trout	1	1	0	233 (210-256)	131 (106-156)

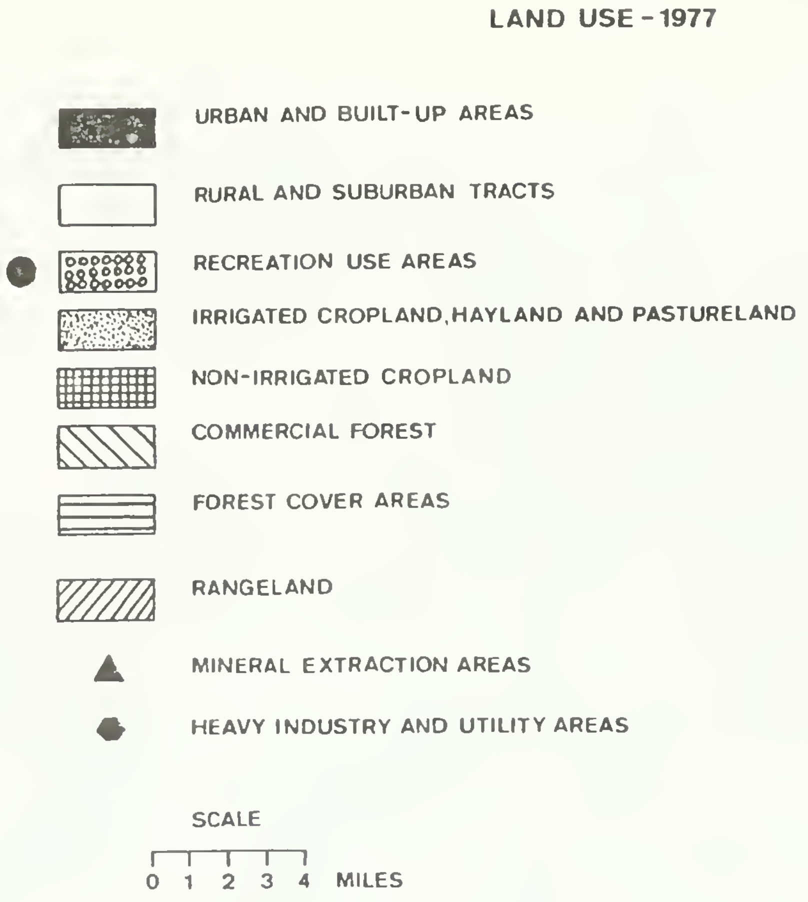
APPENDIX TABLE 17. Catch statistics for salmonids collected in the Darby and Tucker sections of the Bitterroot River during the spring of 1984. Range in parentheses.

SECTION	SPECIES	MARKED	CAPTURED	RECAPTURED	MEAN LENGTH (MM)	MEAN WEIGHT (GM)
Darby	Rainbow Trout	310	262	52	323 (73-500)	378 (10-1080)
	Brown Trout	135	141	43	331 (70-559)	449 (10-1540)
	Cutthroat Trout	12	20	3	344 (157-411)	449 (40-770)
	Brook Trout	9	12	0	172 (94-283)	66 (10-230)
	Bull Trout	6	6	2	323 (280-433)	457 (220-710)
	Mountain Whitefish	315	299	13	275 (175-488)	204 (50-1130)
Tucker (East Channel)	Rainbow Trout	121	95	13	333 (75-533)	484 (10-1530)
	Brown Trout	206	182	43	309 (82-583)	448 (10-1810)
	Cutthroat Trout	5	6	1	326 (181-408)	449 (70-780)
	Brook Trout	5	5	0	182 (103-297)	81 (10-260)
	Mountain Whitefish	323	401	22	266 (110-433)	195 (10-820)
Tucker (West Channel)	Rainbow Trout	169	97	22	363 (71-625)	559 (10-2260)
	Brown Trout	194	154	43	329 (100-544)	459 (10-1690)
	Cutthroat Trout	3	2	0	284 (233-365)	298 (150-590)
	Brook Trout	2	3	0	179 (124-337)	102 (10-390)
	Bull Trout	0	2	0	265 (263-267)	170 (160-180)
	Mountain Whitefish	235	257	19	268 (107-391)	197 (10-600)

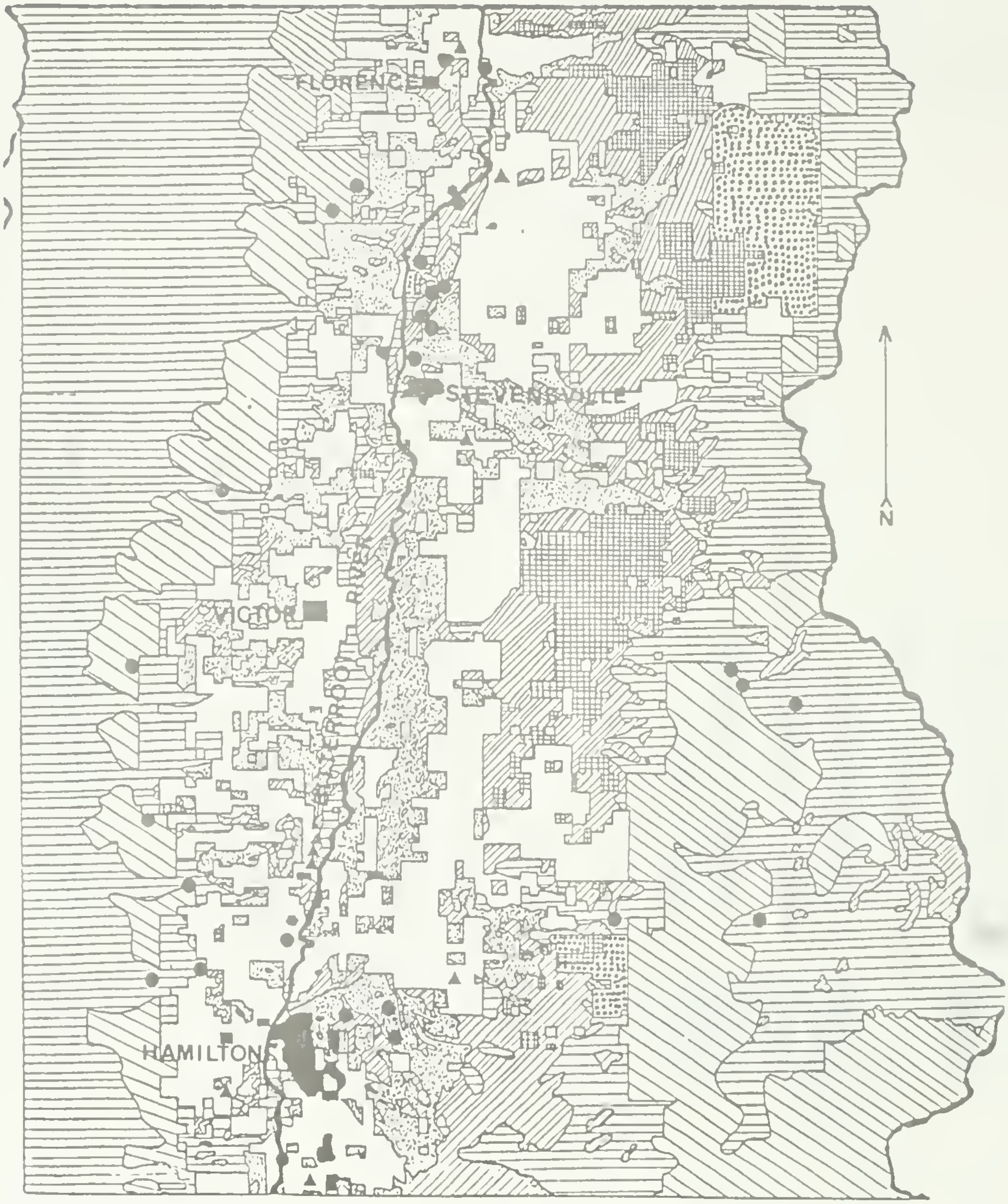
APPENDIX TABLE 18. Catch statistics for salmonids collected in the Darby and Tucker sections of the Bitterroot River during the fall of 1984. Range in parentheses.

SECTION	SPECIES	MARKED	CAPTURED	RECAPTURED	MEAN LENGTH (MM)	MEAN WEIGHT (GM)
Darby	Rainbow Trout	333	281	19	231 (62-457)	212 (5-1140)
	Brown Trout	305	190	30	237 (90-582)	231 (10-2330)
	Cutthroat Trout	15	25	3	292 (191-440)	295 (60-820)
	Brook Trout	41	18	2	191 (90-291)	92 (10-230)
	Bull Trout	8	4	1	313 (175-418)	354 (50-690)
Tucker (East Channel)	Rainbow Trout	138	163	24	283 (72-510)	330 (5-1130)
	Brown Trout	200	189	35	300 (89-558)	357 (10-1700)
	Cutthroat Trout	0	1	0	426 ---	850 ---
	Brook Trout	2	2	1	250 (215-270)	170 (120-230)
	Bull Trout	1	0	0	262 ---	170 ---
Tucker (West Channel)	Rainbow Trout	123	127	17	243 (74-445)	212 (5-910)
	Brown Trout	186	187	22	290 (83-605)	388 (10-2190)
	Cutthroat Trout	7	4	0	286 (204-362)	256 (90-500)
	Brook Trout	6	1	0	221 (79-311)	156 (10-330)

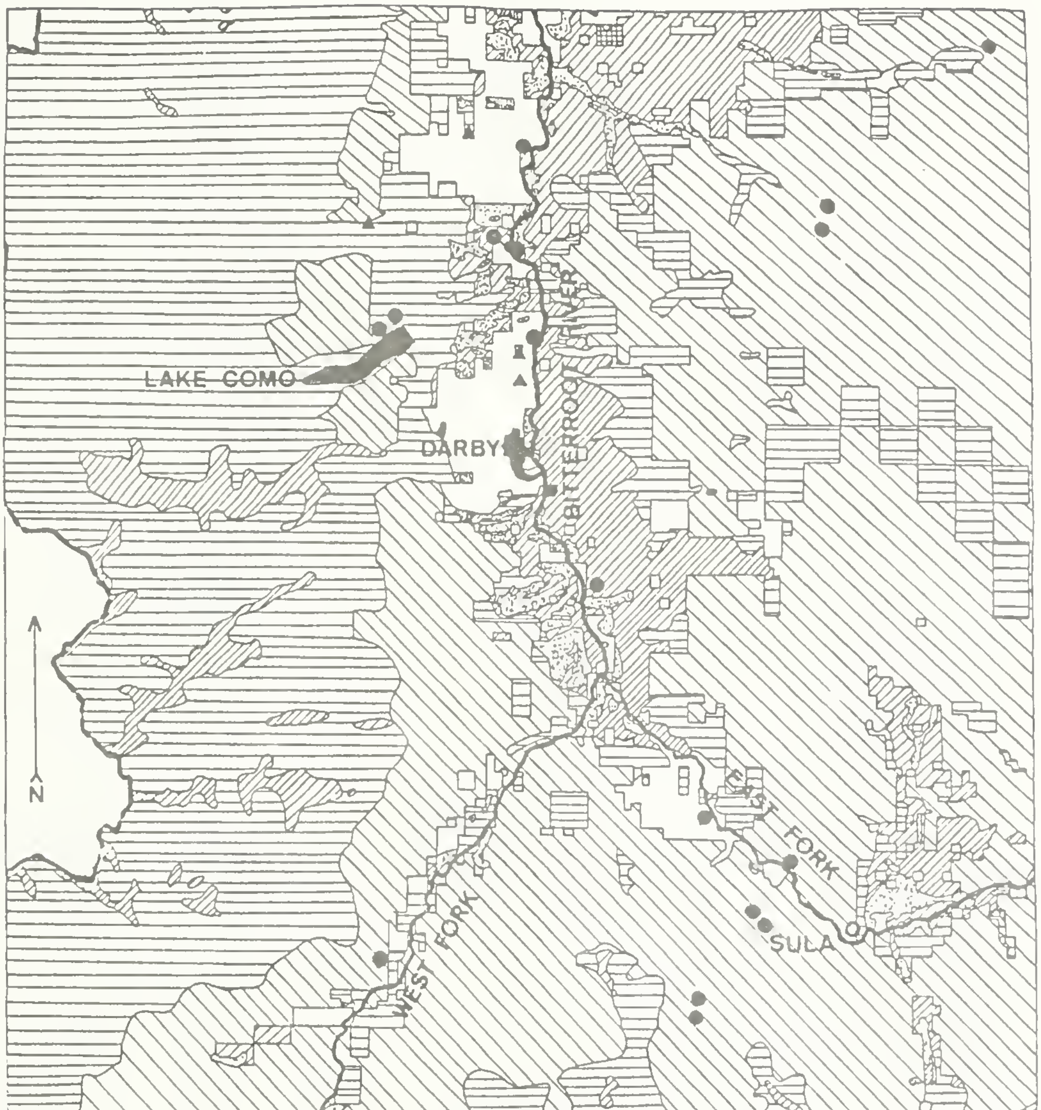
APPENDIX FIGURES



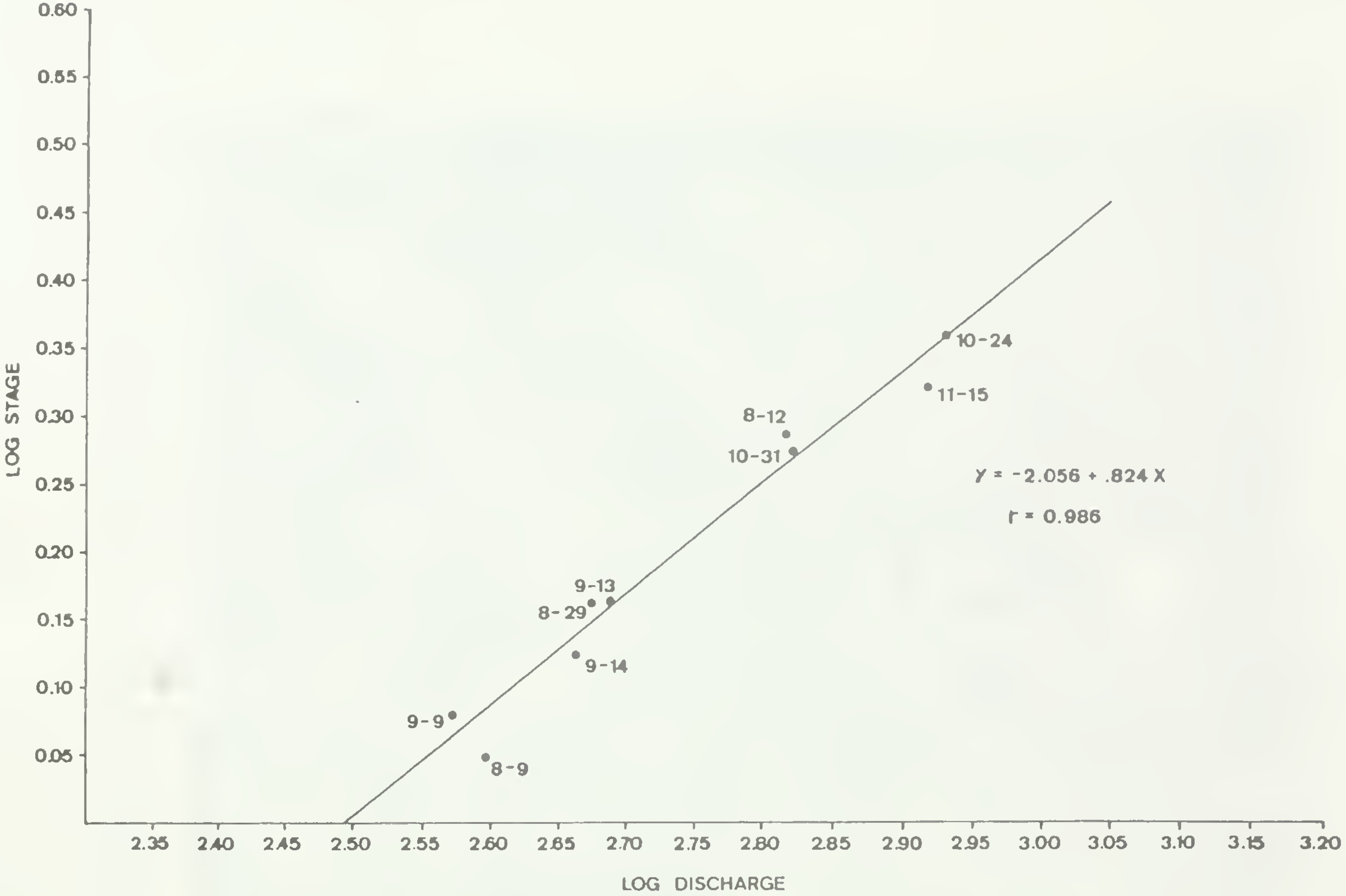
APPENDIX FIGURE 1. Key to the features of the land use maps for the Bitterroot River.



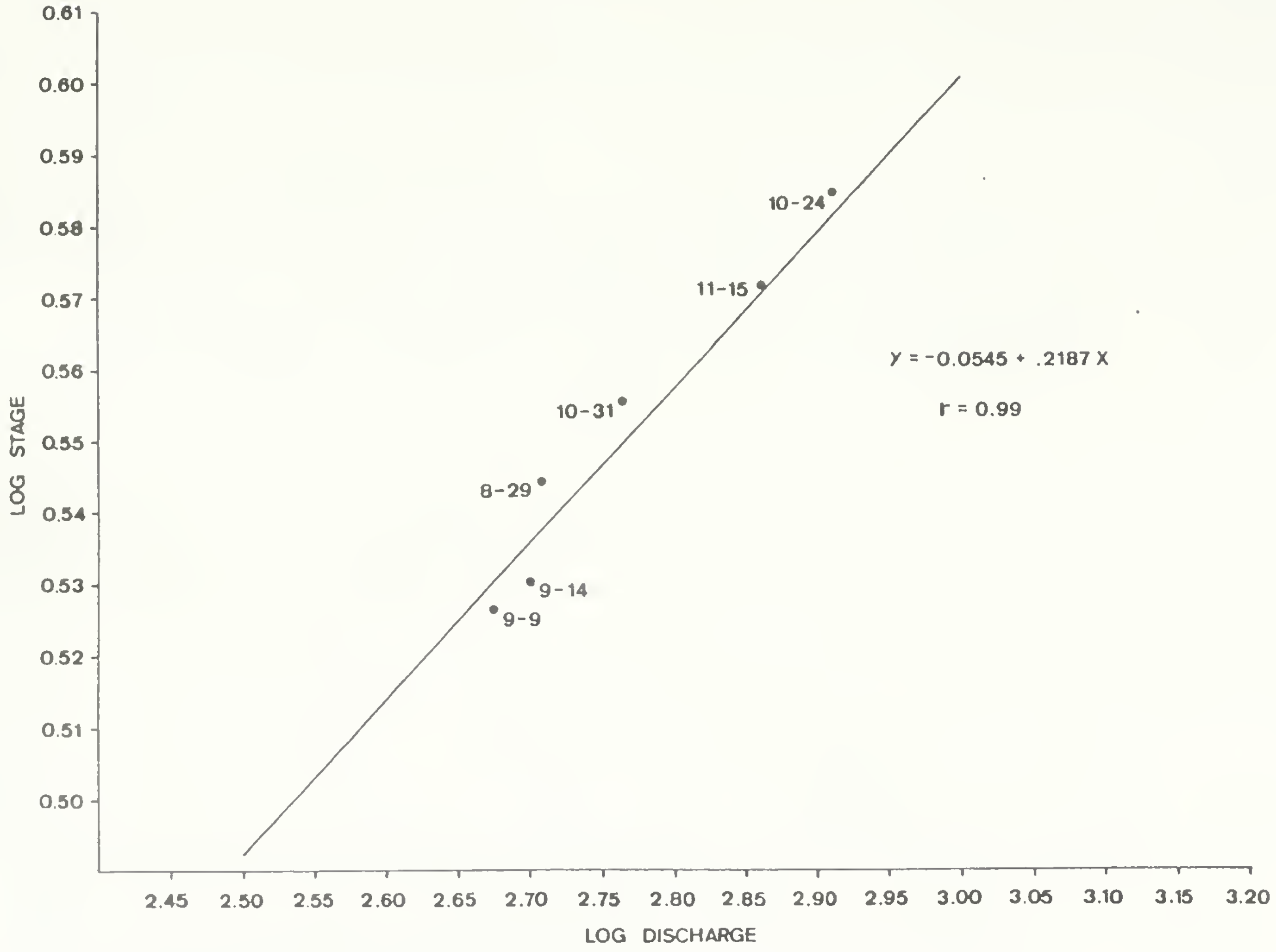
APPENDIX FIGURE 2. Land use patterns of the central Bitterroot basin.



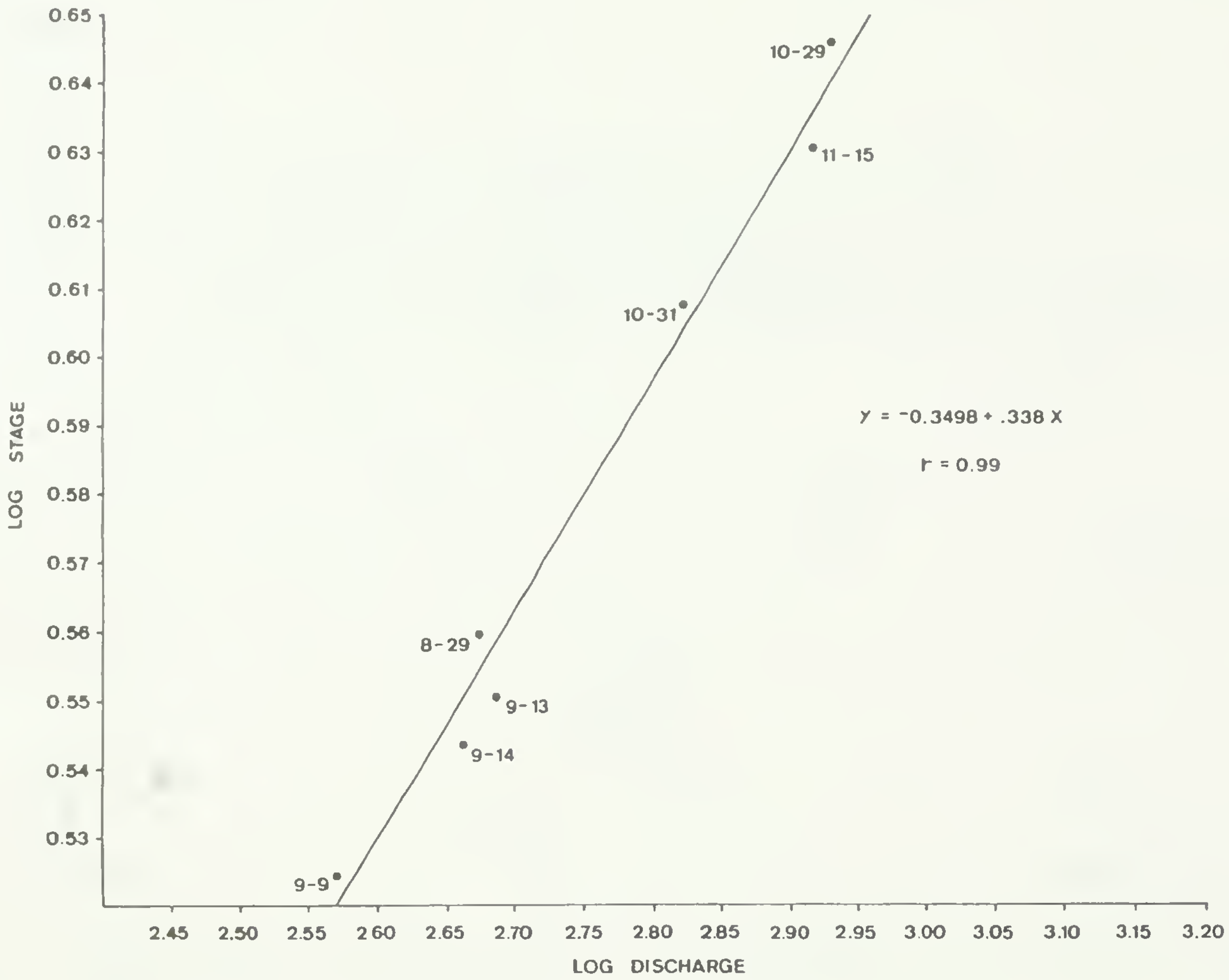
APPENDIX FIGURE 3. Land use patterns of the upper Bitterroot basin.



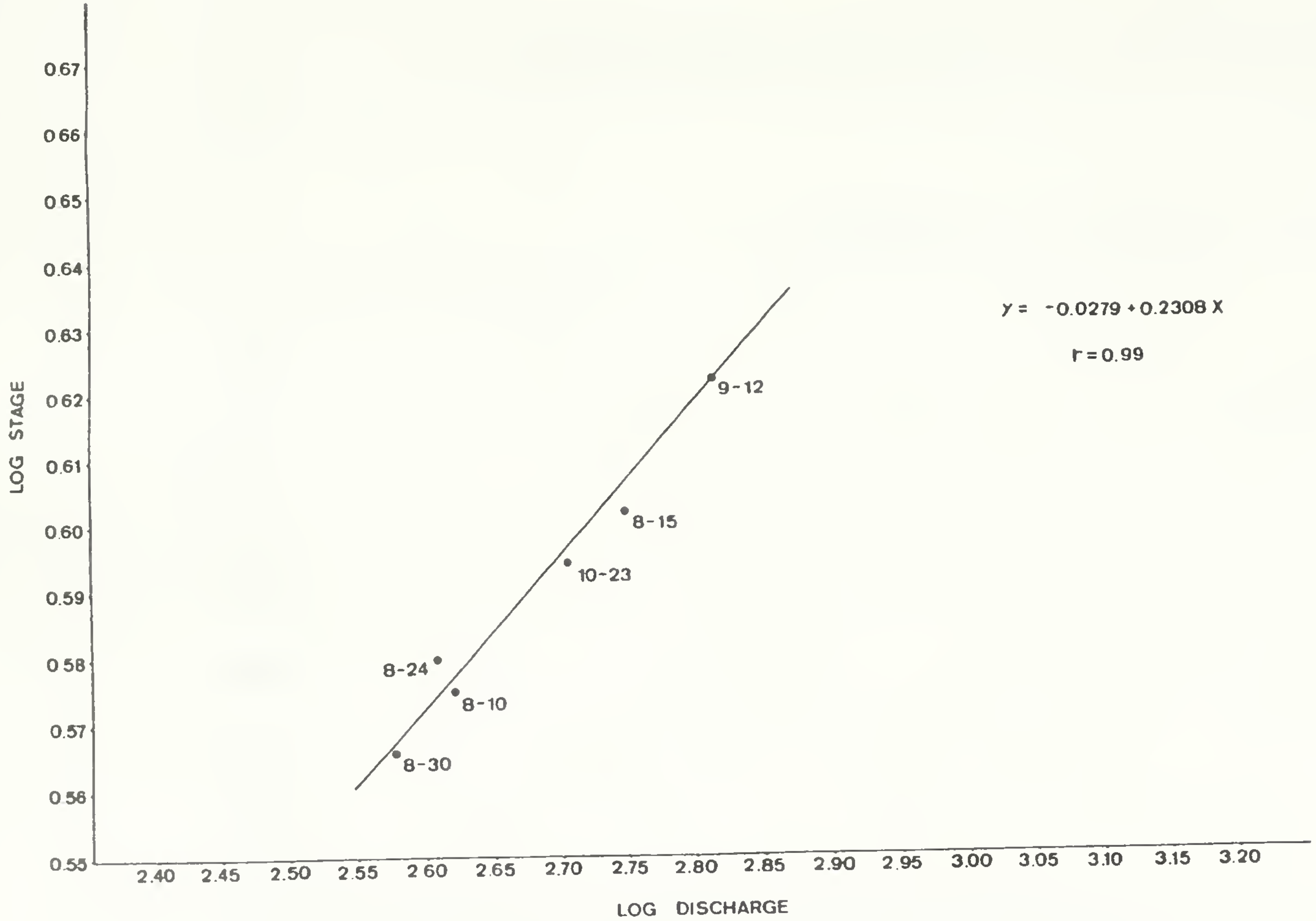
APPENDIX FIGURE 4. Stage-discharge rating curve derived for the staff gage at Bell crossing during 1983.



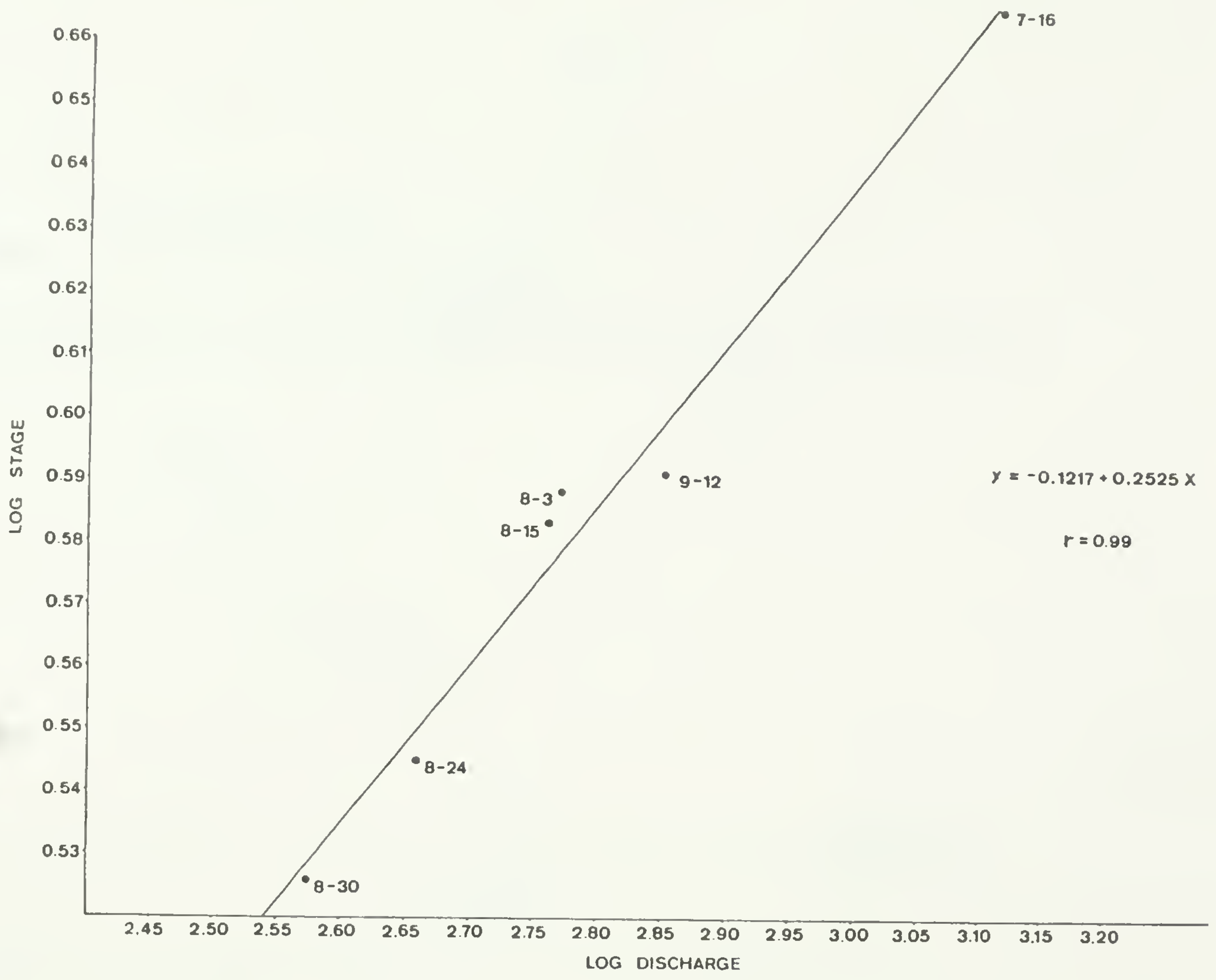
APPENDIX FIGURE 5. Stage-discharge rating curve derived for the water level recorder at Woodside crossing during 1983.



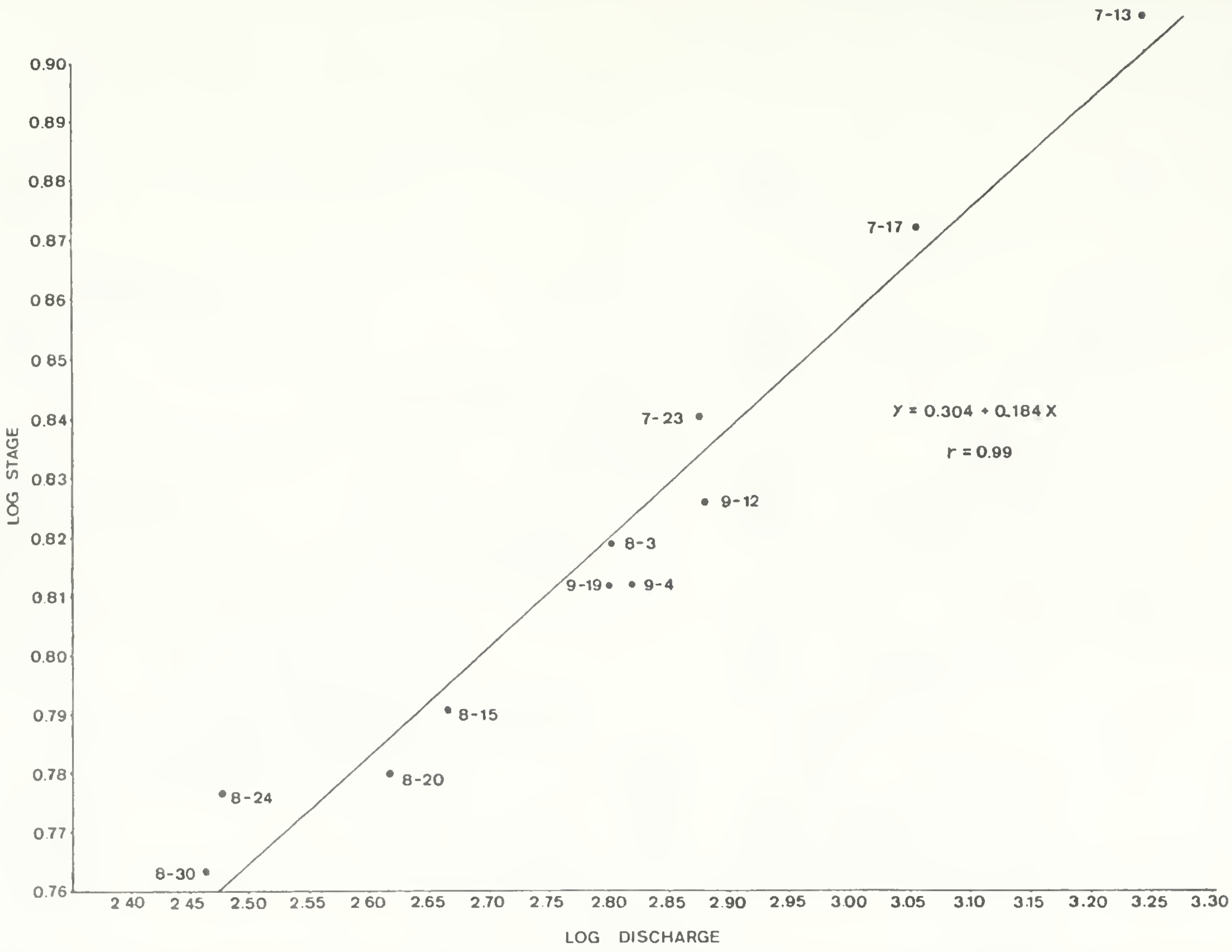
APPENDIX FIGURE 6. Stage-discharge rating curve derived for the water level recorder at Bell Crossing during 1983.



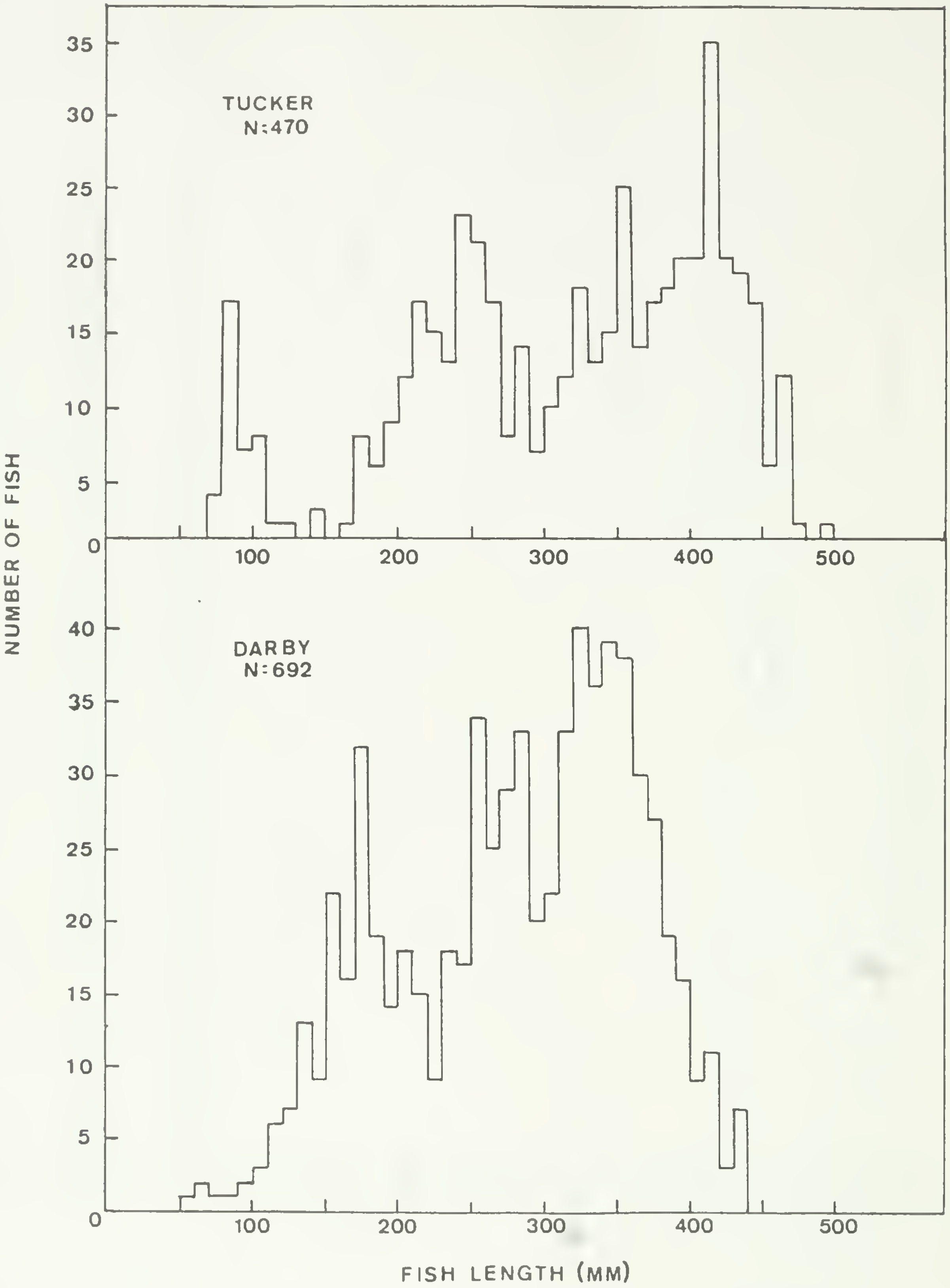
APPENDIX FIGURE 7. Stage-discharge rating curve derived for the water level recorder at Hamilton during 1984.



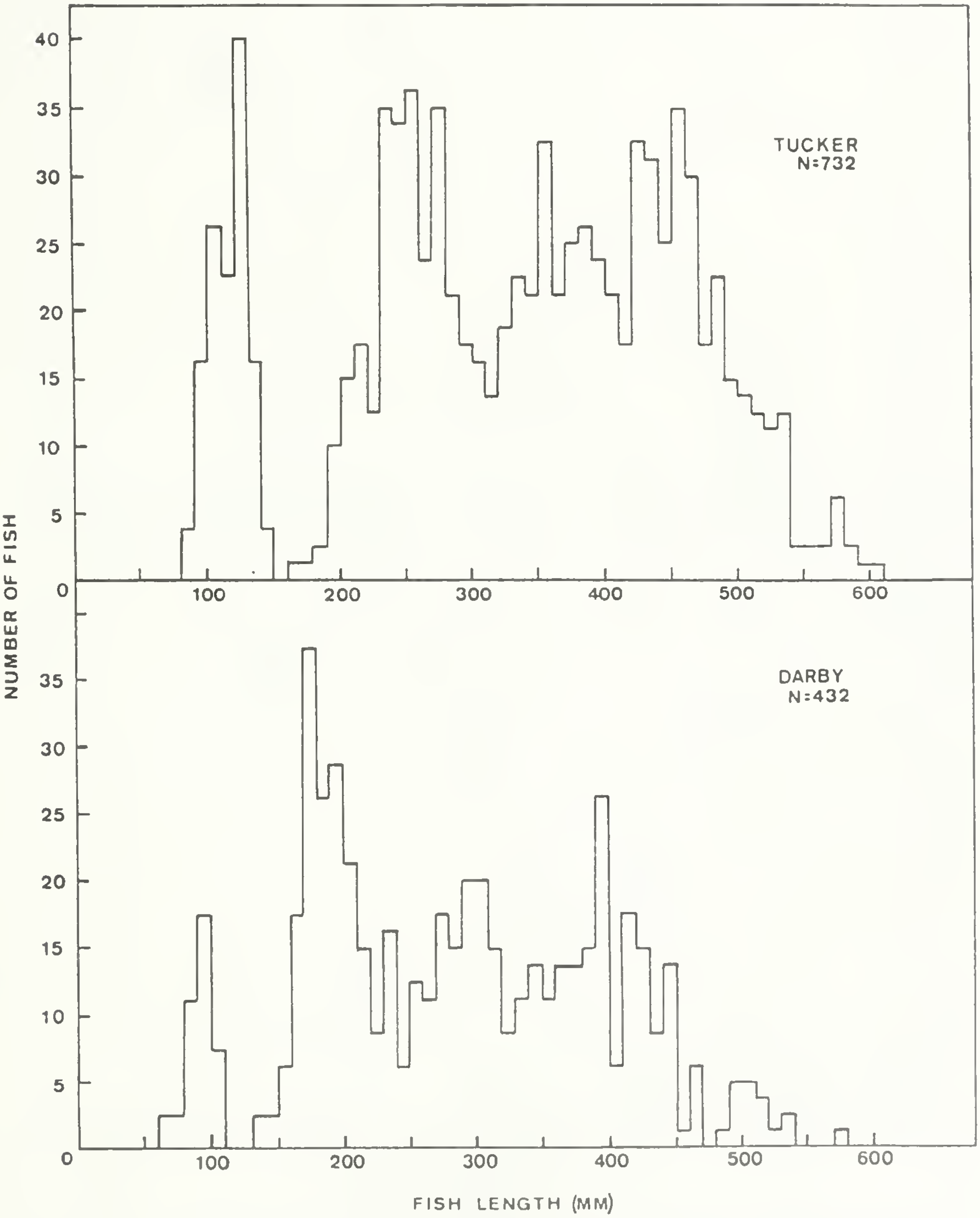
APPENDIX FIGURE 8. Stage-discharge rating curve derived for the water level recorder at Woodside crossing during 1984.



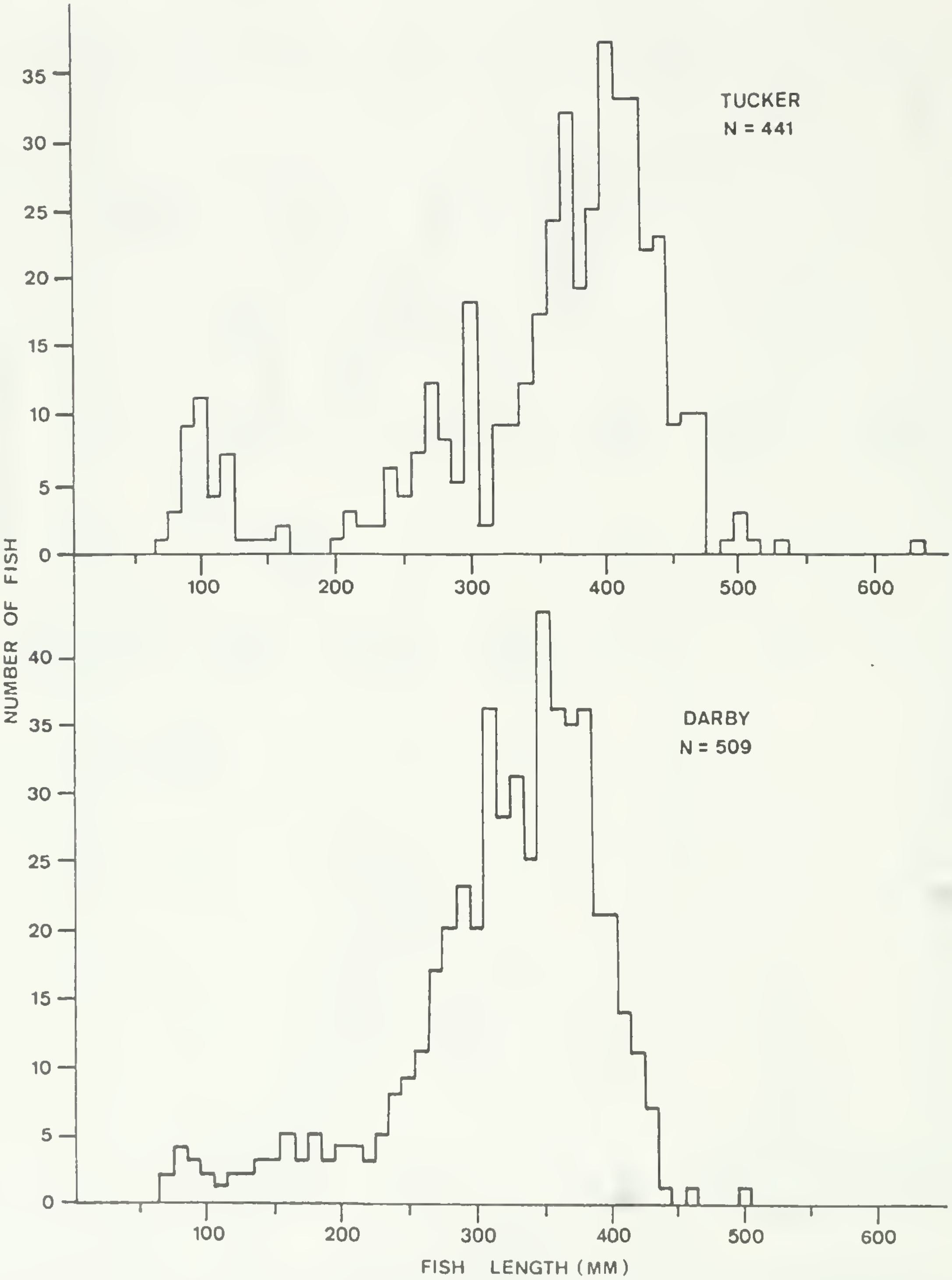
APPENDIX FIGURE 9. Stage-discharge rating curve derived for the water level recorder at Bell crossing during 1984.



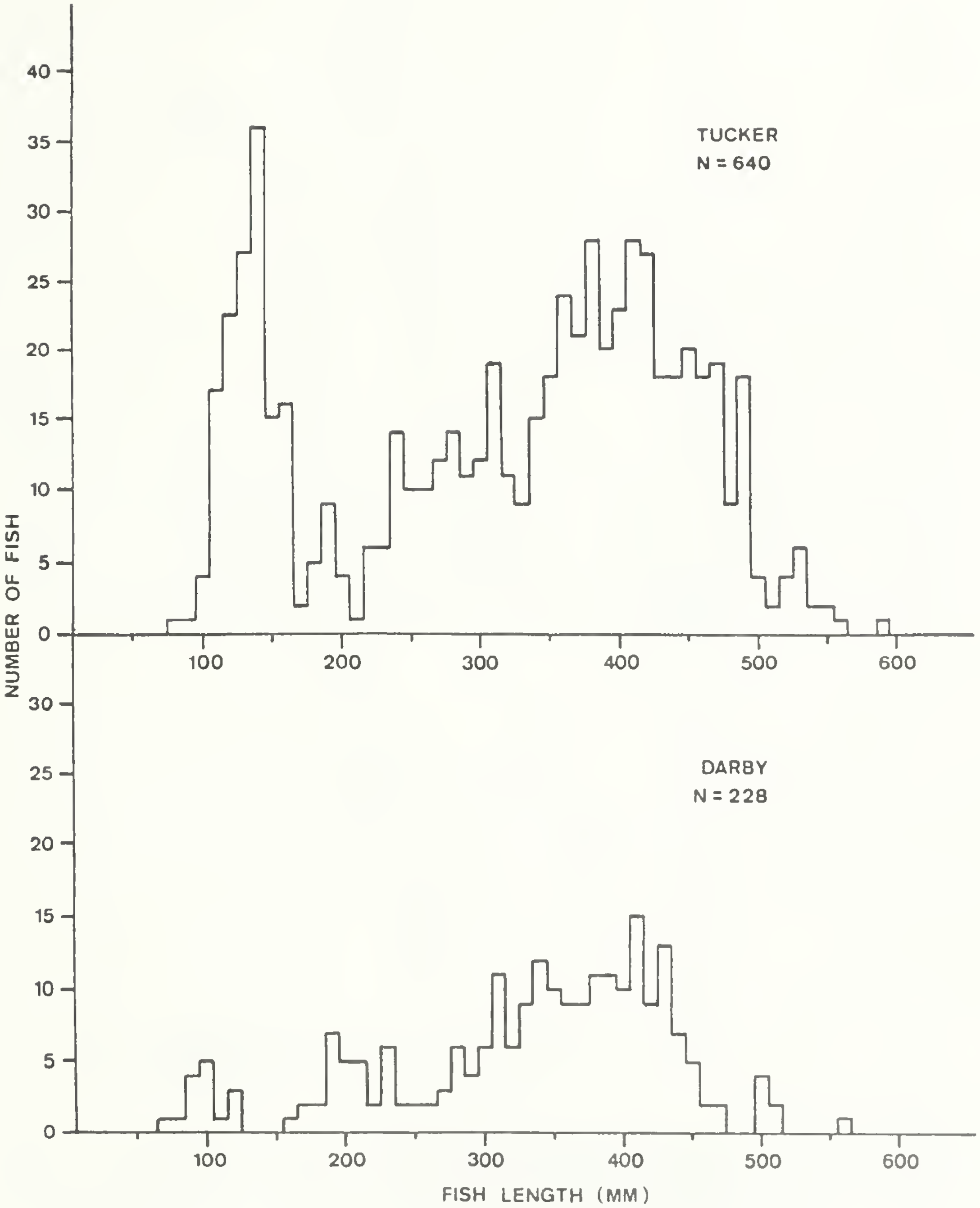
APPENDIX FIGURE 10. Length frequency distributions of rainbow trout collected in the Darby and Tucker sections during the fall of 1983.



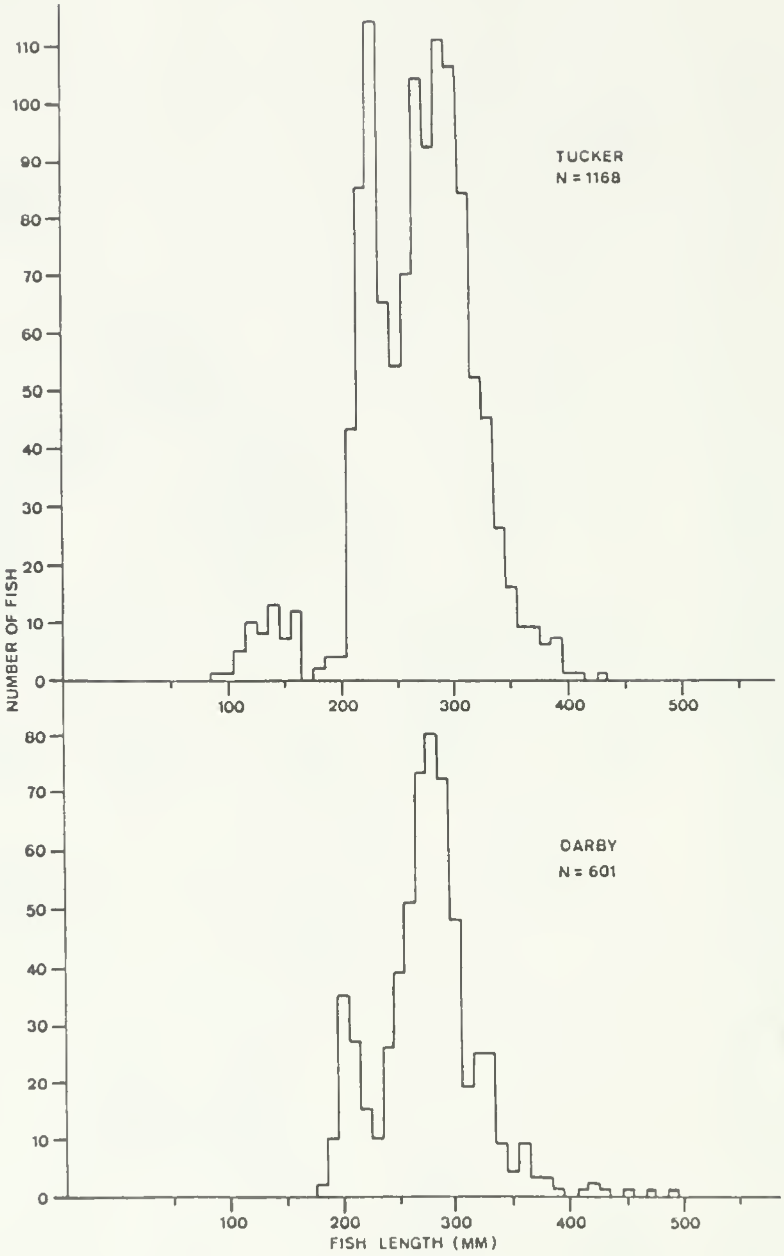
APPENDIX FIGURE 11. Length frequency distributions of brown trout collected in the Darby and Tucker sections during the fall of 1983.



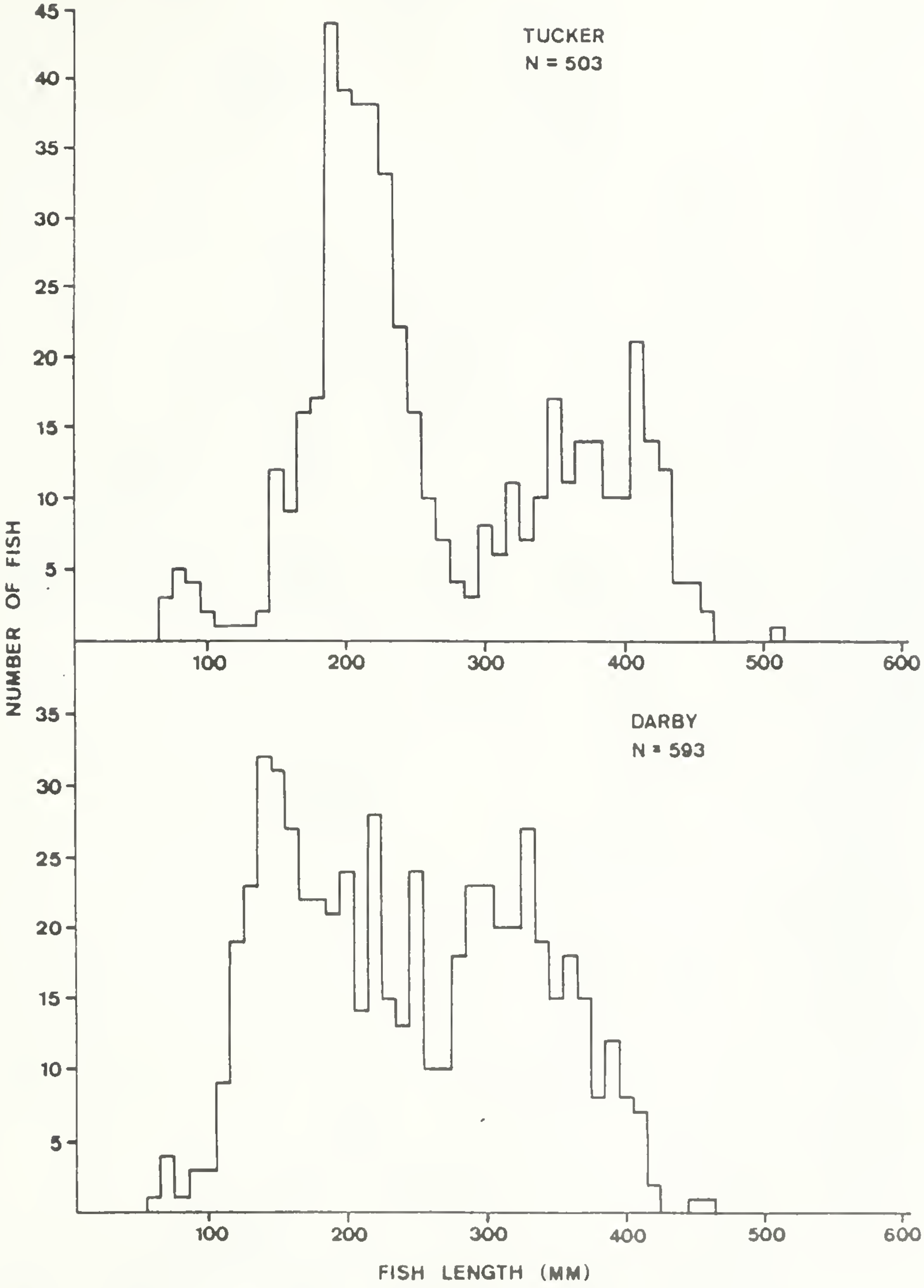
APPENDIX FIGURE 12. Length frequency distributions of rainbow trout collected in the Darby and Tucker sections during the spring of 1984.



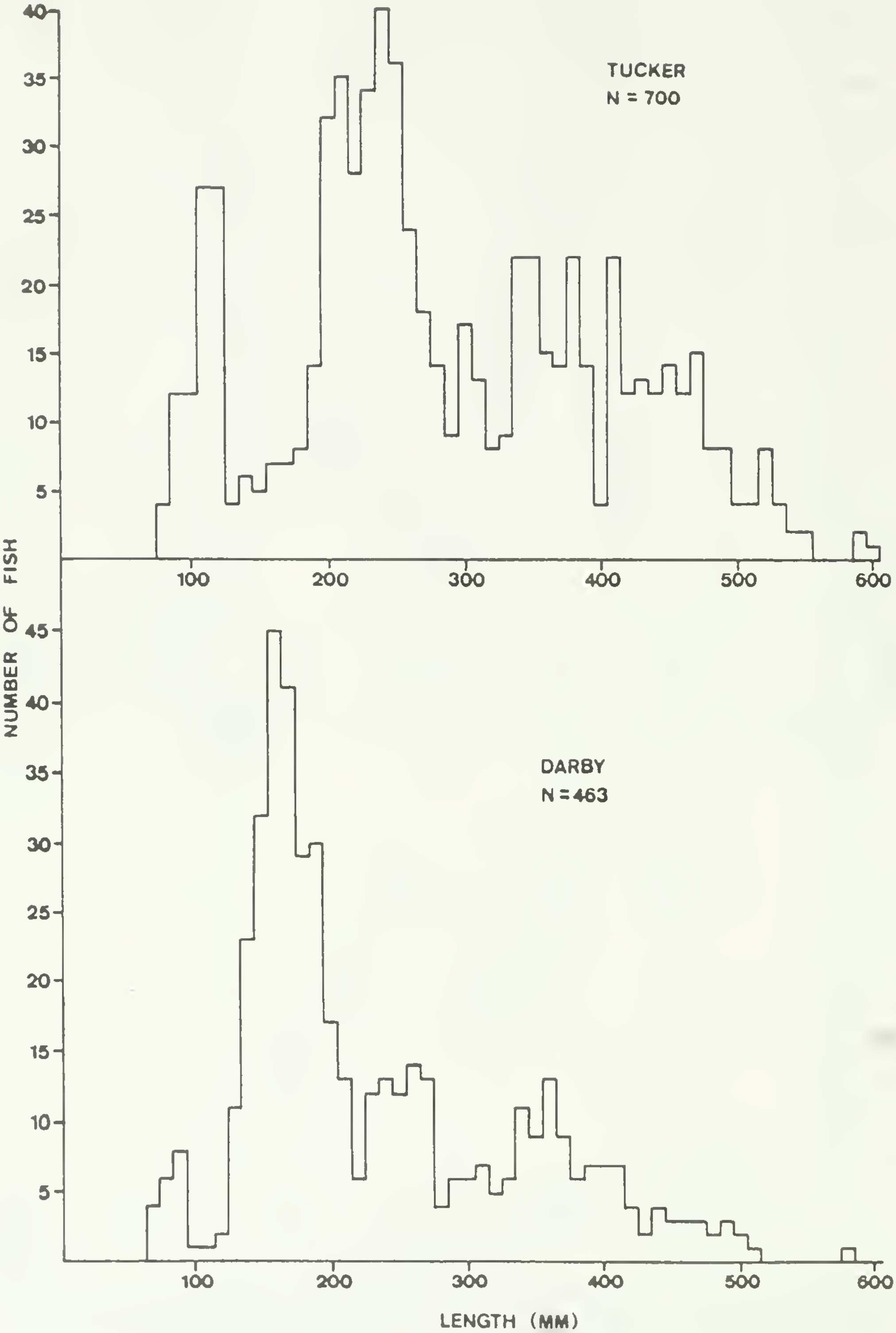
APPENDIX FIGURE 13. Length frequency distributions of brown trout collected in the Darby and Tucker sections during the spring of 1984.



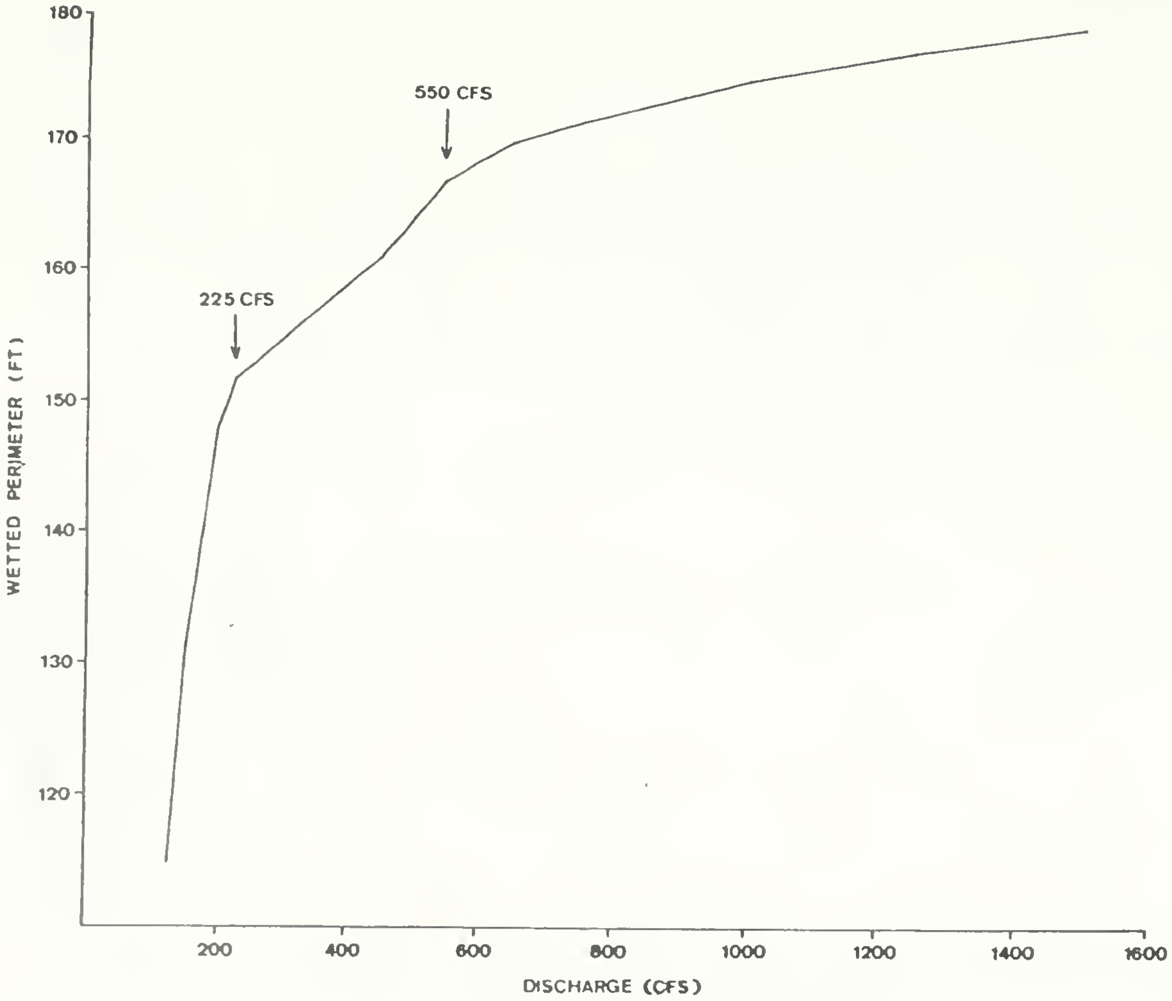
APPENDIX FIGURE 14. Length frequency distributions of mountain whitefish collected in the Darby and Tucker sections during the spring of 1984.



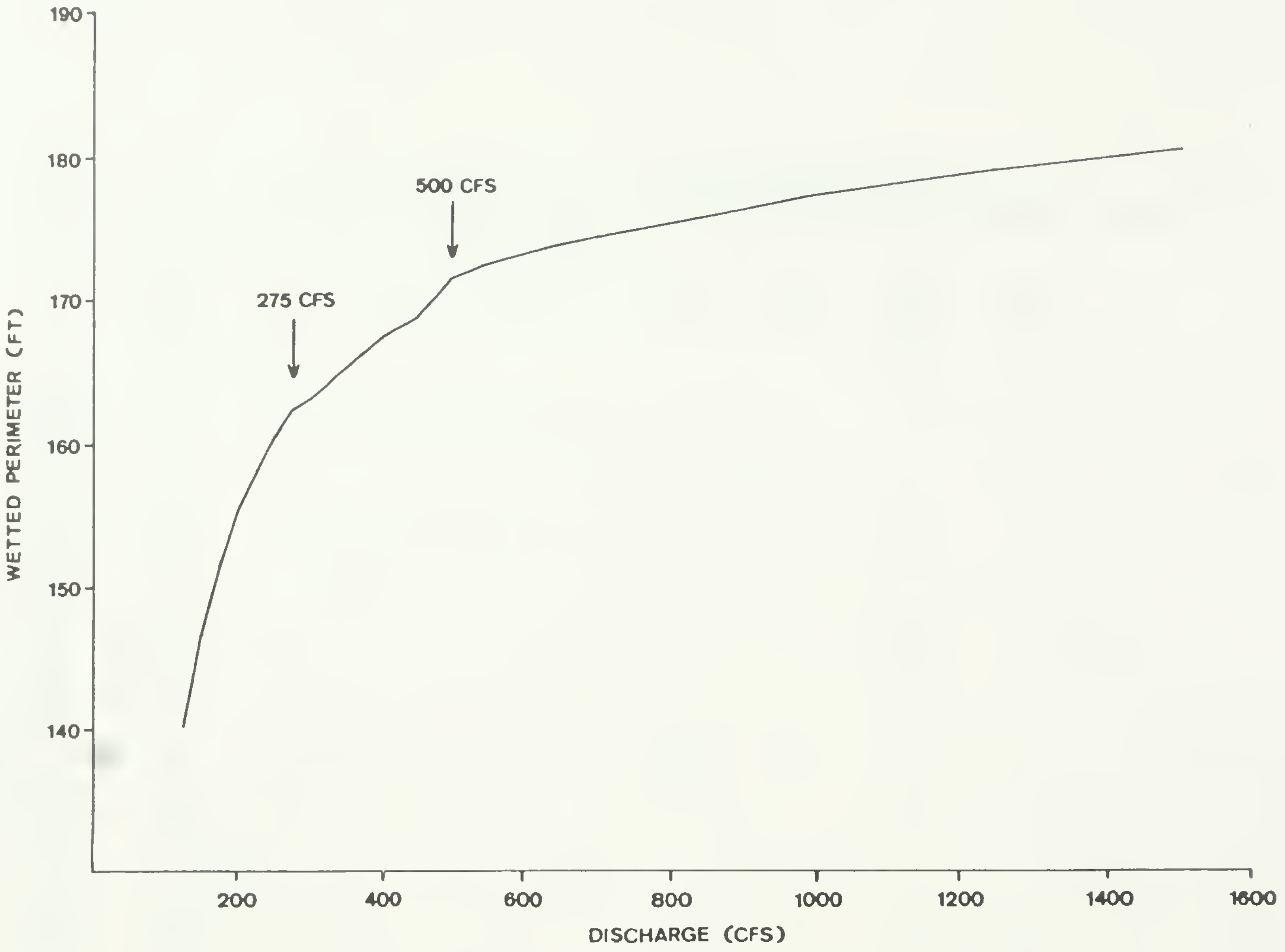
APPENDIX FIGURE 15. Length frequency distributions of rainbow trout collected in the Darby and Tucker sections during the fall of 1984.



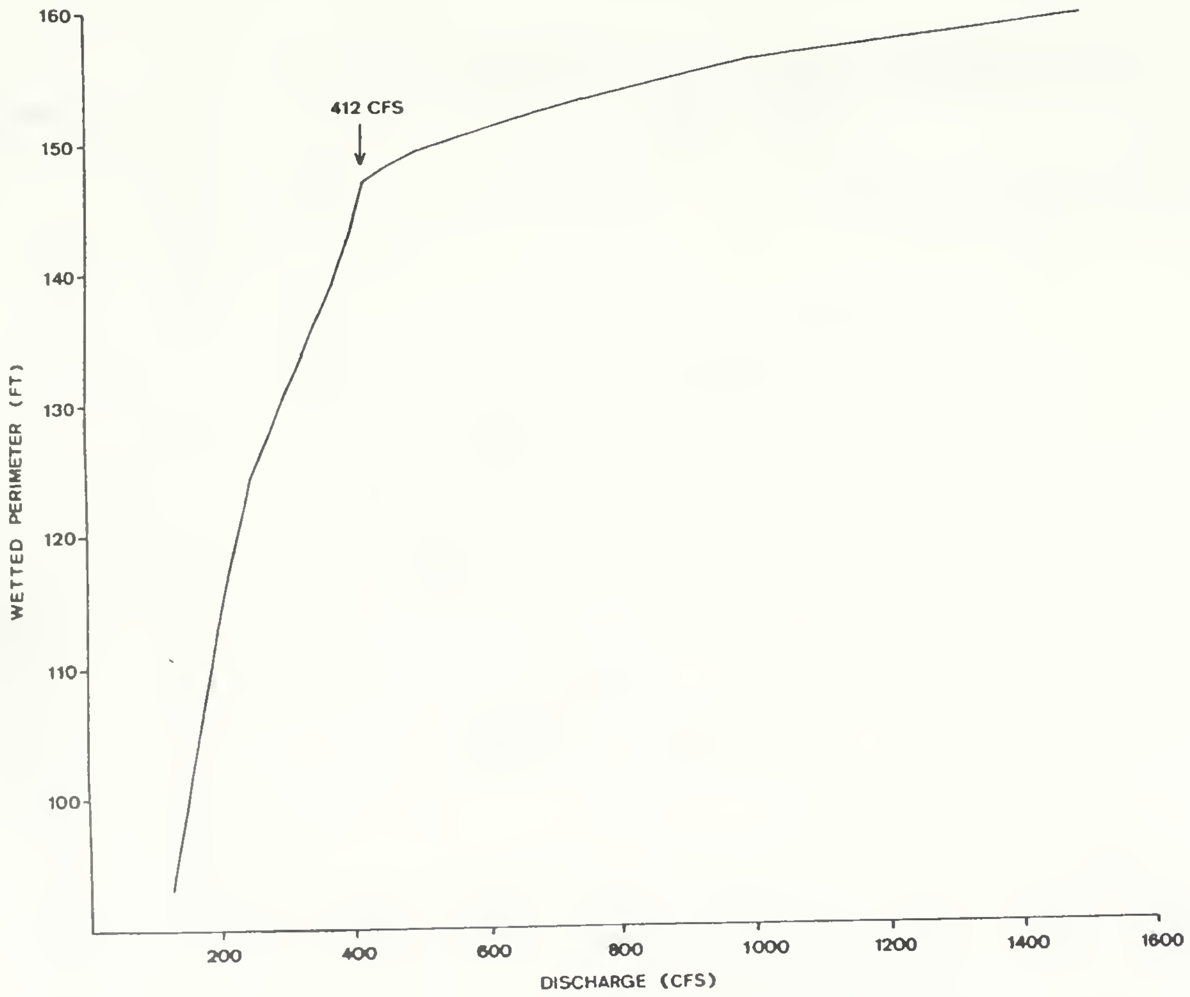
APPENDIX FIGURE 16. Length frequency distributions of brown trout collected in the Darby and Tucker sections during the fall of 1984.



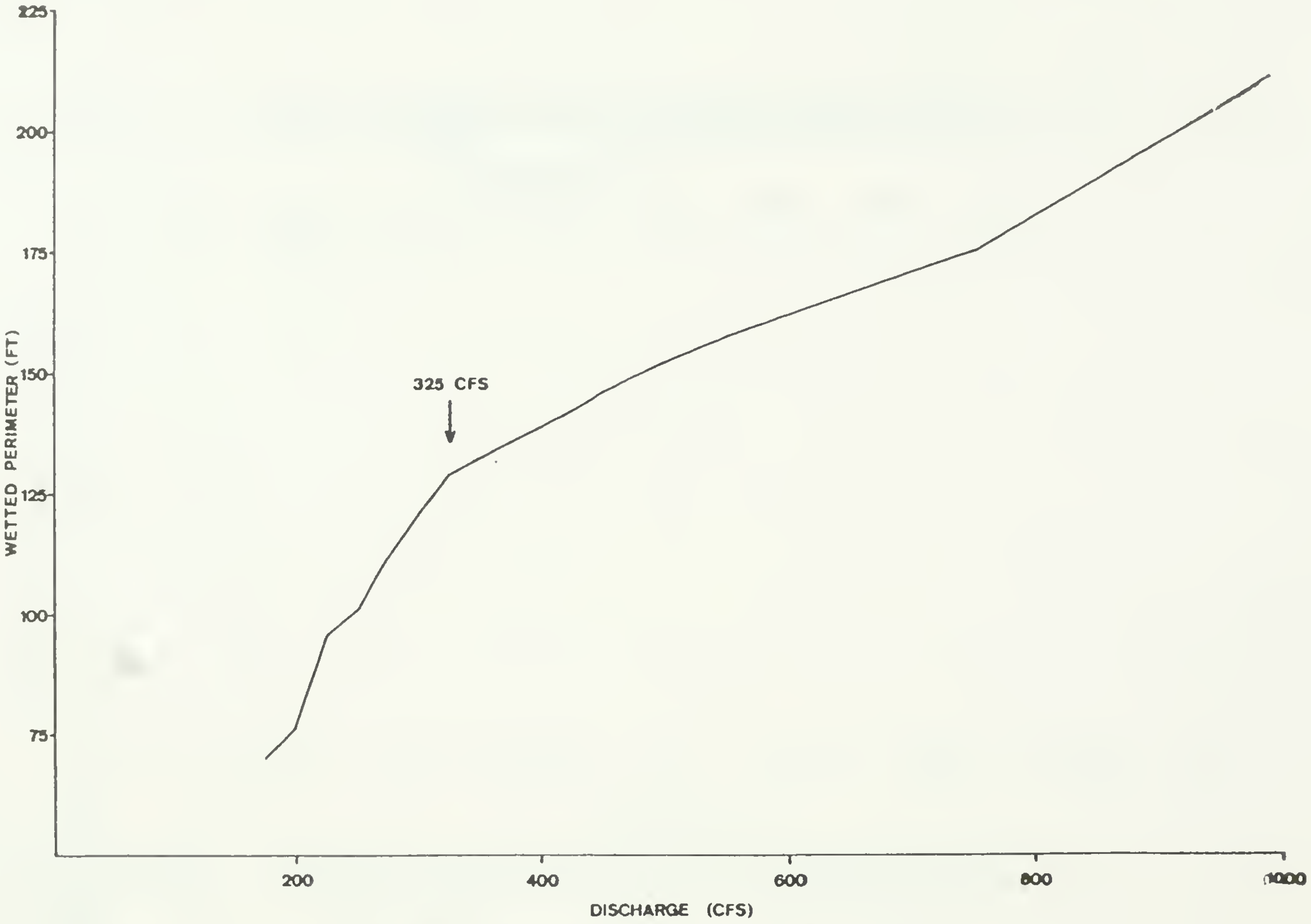
APPENDIX FIGURE 17. Average relationship between wetted perimeter and discharge for three cross sections of a riffle in the Darby section of the Bitterroot River.



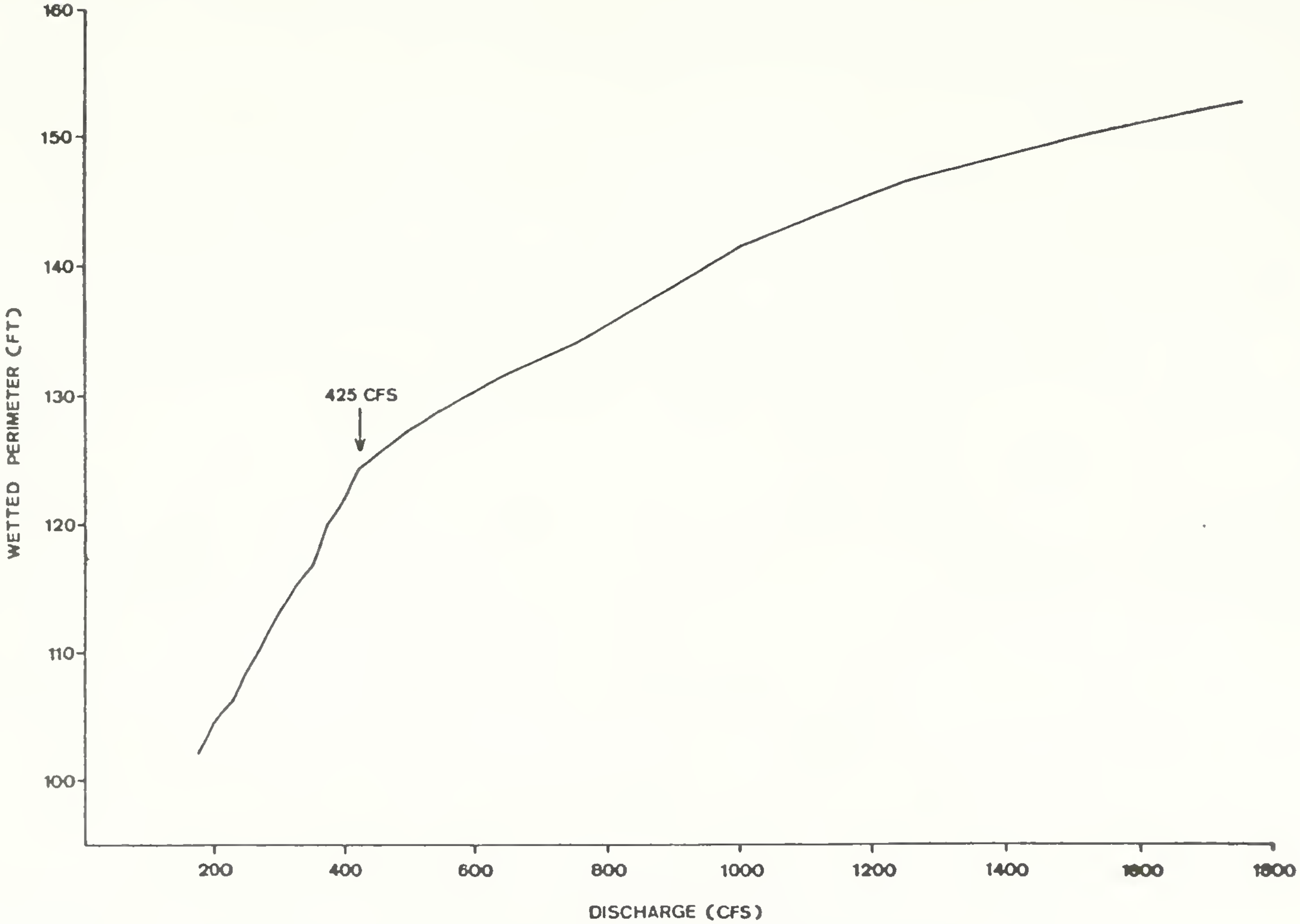
APPENDIX FIGURE 18. Average relationship between wetted perimeter and discharge for three cross sections of a riffle in the Darby section of the Bitterroot River.



APPENDIX FIGURE 19. Average relationship between wetted perimeter and discharge for three cross sections of a riffle in the Darby section of the Bitterroot River.



APPENDIX FIGURE 20. Average relationship between wetted perimeter and discharge for three cross sections of a riffle near the Tucker section of the Bitterroot River.



APPENDIX FIGURE 21. Average relationship between wetted perimeter and discharge for three cross sections of a riffle near the Tucker section of the Bitterroot River.

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